

เอกสารแนบที่ 2.26

ประกาศนโยบายการอนุรักษ์การได้ยิน

เอกสารแนบที่ 2.27

แผนการตรวจสอบสภาพเครื่องจักร
(Preventive Maintenance Plan Year 2022)

Maintenance Plan	Maint Item	Group	Maint Item Text	Call Number	Planned date	Sched. Start Date	Functional Loc.	Equipment	Description
78PFCNMP0601	29053	78PCNP06	ตรวจรักษา เปลี่ยน PACKING PUMP	10.00	01/07/2022	01/07/2022	7788P1-CR1-EI-PU925	E/07810E1-2610040	ACID PUMP
78PCFCNP0601	34813	78PCNP06	เปลี่ยน PACKING PUMP	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-PU0010	E/07810CP-2100290	OIL PUMP OF GRINDING MACHINE
78PCPLGP0601	34820	78PLGG06	เปลี่ยนจารบี Coupling Gear (Shell GADUS	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-GCO3016	E/07810CP-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCPLGP0601	34814	78PLGP06	เปลี่ยนจารบี COUPLING PUMP (Shell GADUS	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-PU0010	E/07810CP-2100290	OIL PUMP OF GRINDING MACHINE
78PCPLGP0601	34818	78PLGG06	ตรวจสภาพน้ำมัน Gear (Omala S4 GX)	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-GCO3016	E/07810CP-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCPLGP0601	34812	78PLGP06	ตรวจสภาพน้ำมัน PUMP	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-PU0010	E/07810CP-2100290	OIL PUMP OF GRINDING MACHINE
78PCPLGP0601	34811	78PLGP06	ตรวจสภาพน้ำมัน Tank	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-TK0030	E/07810CP-1530160	HYDRAULIC TANK FOR LOG LIFT
78PCPMCMG0601	34806	78PMCMG06	ตรวจสภาพ Chain,Bush,Coupling,Flight	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-MG6005	E/07810CP-1010230	RACKAR
78PCPMCMG0601	34819	78PMCMG06	ตรวจสภาพ Pulley & V-Belt	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-GCO3016	E/07810CP-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCPMCMG0602	34821	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Gear	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-GCO3016	E/07810CP-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCPMCMG0601	34816	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Pump	7.00	21/07/2022	21/07/2022	7788P1-RM-CP-PU0010	E/07810CP-2100290	OIL PUMP OF GRINDING MACHINE
78PCPMCMG0601	34831	78PCNP06	เปลี่ยน PACKING PUMP	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-M1605	E/07810CP-2100080	TABLE LIFT HYDRAULIC PUMP
78PCPMCMG0601	34829	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-TI611	E/07810PM-1530010	TABLE LIFT HYDRAULIC TANK
78PCPMCMG0602	34827	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-M1605	E/07810PM-2100080	TABLE LIFT HYDRAULIC PUMP
78PCPMCMG0601	34838	78PLGG06	เปลี่ยนจารบี Coupling Gear (Shell GADUS	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-GM1604	E/07810PM-3040410	RED.GEAR OF ROTARY KNIFE CUTTER
78PCPMCMG0601	34836	78PLGP06	เปลี่ยนจารบี COUPLING PUMP (Shell GADUS	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-M1605	E/07810PM-2100080	TABLE LIFT HYDRAULIC PUMP
78PCPMCMG0601	34830	78PLGP06	ตรวจสภาพน้ำมัน Gear (Omala S4 GX)	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-M1604	E/07810PM-3040410	RED.GEAR OF ROTARY KNIFE CUTTER
78PCPMCMG0601	34830	78PLGP06	ตรวจสภาพน้ำมัน PUMP	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-M1605	E/07810PM-2100080	TABLE LIFT HYDRAULIC PUMP
78PCPMCMG0601	34829	78PLGP06	ตรวจสภาพน้ำมัน Tank	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-TI611	E/07810PM-1530010	TABLE LIFT HYDRAULIC TANK
78PCPMCMG0601	34824	78PMCMG06	ตรวจสภาพ Bush,Bearing,Belt,Chain	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-M1658-T1	E/07810PM-0520010	HDP.NO.2 FELT TOP ROLL NO.1
78PCPMCMG0601	34837	78PMCMG06	ตรวจสภาพ Pulley & V-Belt	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-GM1504	E/07810PM-3040410	RED.GEAR OF ROTARY KNIFE CUTTER
78PCPMCMG0602	34839	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Gear	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-GM1604	E/07810PM-3040410	RED.GEAR OF ROTARY KNIFE CUTTER
78PCPMCMG0601	34834	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Pump	7.00	21/07/2022	21/07/2022	7788P1-CR1-PM-M1605	E/07810PM-2100080	TABLE LIFT HYDRAULIC PUMP
78PCPMCMG0601	34801	78PCNP06	เปลี่ยน PACKING PUMP	7.00	21/07/2022	21/07/2022	7788P1-RM-PU020	E/07810RM-2620990	STATIONARY ECO SUMP PUMP
78PCPMCMG0601	34802	78PLGP06	เปลี่ยนจารบี Coupling Pump (Shell GADUS	7.00	21/07/2022	21/07/2022	7788P1-RM-PU020	E/07810RM-2620990	STATIONARY ECO SUMP PUMP
78PCPMCMG0601	34781	78PLGP06	ตรวจสภาพน้ำมัน PUMP	7.00	21/07/2022	21/07/2022	7788P1-RM-PU020	E/07810RM-2620990	STATIONARY ECO SUMP PUMP
78PCPMCMG0601	34804	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Pump	7.00	21/07/2022	21/07/2022	7788P1-RM-PU020	E/07810RM-2620990	STATIONARY ECO SUMP PUMP
78PCPMCMG0601	34940	78PCNP06	เปลี่ยน PACKING PUMP	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1709C	E/07810C1-2610930	PULP STORAGE RECIR. PUMP
78PCPMCMG0602	34955	78PCNP06	เปลี่ยน PACKING PUMP	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1531	E/07810BE-2000710	NaOH METERING PUMP NO.1
78PCPMCMG0601	34938	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1546	E/07810BE-2000050	HYDROGEN PEROXIDE STORAGE PUMP
78PCPMCMG0601	36292	78PLGC01	สับจาร์ Chain,Bush,Coupling,Flight	41.00	22/07/2022	22/07/2022	7788P1-CR1-BE-CO1501	E/07810BE-0060060	C-SHREDDER CONVEYOR
78PCPMCMG0601	36249	78PLGG01	สับจาร์ Coupling Gear (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GM1510	E/07810BE-3040450	RED. GEAR OF EXTRACTOR
78PCPMCMG0601	36251	78PLGG01	สับจาร์ Coupling Gear (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GD0010	E/07810BE-6002680	RED. GEAR OF EXTRACTOR
78PCPMCMG0601	34947	78PLGG06	เปลี่ยนจารบี Coupling Gear (Shell GADUS	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GM1510	E/07810BE-3040450	RED. GEAR OF EXTRACTOR
78PCPMCMG0602	34962	78PLGG06	เปลี่ยนจารบี Coupling Gear (Shell GADUS	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GD0010	E/07810BE-6002680	RED. GEAR OF EXTRACTOR
78PCPMCMG0601	36248	78PLGP01	สับจาร์ COUPLING PUMP (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1531	E/07810C1-2610930	GEAR MOTOR OF CHLORINE AUTO DOOR
78PCPMCMG0601	36250	78PLGP06	เปลี่ยนจารบี COUPLING PUMP (Shell GADUS	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1709C	E/07810C1-2610930	PULP STORAGE RECIR. PUMP
78PCPMCMG0601	34941	78PLGP06	เปลี่ยนจารบี COUPLING PUMP (Shell GADUS	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1531	E/07810BE-2000710	NaOH METERING PUMP NO.1
78PCPMCMG0602	34956	78PLGP06	เปลี่ยนจารบี COUPLING PUMP (Shell GADUS	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GM1510	E/07810BE-3040450	RED. GEAR OF EXTRACTOR
78PCPMCMG0602	34960	78PLGP06	ตรวจสภาพน้ำมัน Gear (Omala S4 GX)	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GD0010	E/07810BE-6002680	RED. GEAR OF EXTRACTOR
78PCPMCMG0602	34959	78PLGP06	ตรวจสภาพน้ำมัน PUMP	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1709C	E/07810C1-2610930	PULP STORAGE RECIR. PUMP
78PCPMCMG0601	34932	78PMCMG06	ตรวจสภาพ Chain,Bush,Coupling,Flight	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1531	E/07810BE-0060060	C-SHREDDER CONVEYOR
78PCPMCMG0601	34946	78PMCMG06	ตรวจสภาพ Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-CO1501	E/07810BE-3040450	RED. GEAR OF EXTRACTOR
78PCPMCMG0602	34948	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Gear	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GM1510	E/07810BE-6002680	RED. GEAR OF EXTRACTOR
78PCPMCMG0603	34961	78PMCMG06	ตรวจสภาพ Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GD0010	E/07810BE-3040450	RED. GEAR OF EXTRACTOR
78PCPMCMG0604	34963	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GM1510	E/07810BE-6002680	RED. GEAR OF EXTRACTOR
78PCPMCMG0602	34943	78PMCMG06	ตรวจสภาพ Bolt & Rubber Coupling Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1709C	E/07810C1-2610930	PULP STORAGE RECIR. PUMP
78PCPMCMG0602	34958	78PMCMG06	ตรวจสภาพ Chain,Bush,Coupling,Flight	7.00	22/07/2022	22/07/2022	7788P1-CR1-BE-PU1709C	E/07810BE-2000710	NaOH METERING PUMP NO.1
78PCPMCMG0601	36284	78PLGC01	สับจาร์ Chain,Bush,Coupling,Flight	41.00	22/07/2022	22/07/2022	7788P1-CR1-BE-CO1501	E/07810BE-3040450	RED. GEAR OF EXTRACTOR
78PCPMCMG0601	36285	78PLGG01	สับจาร์ Coupling Gear (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-BE-GM1510	E/07810BE-6002680	RED. GEAR OF EXTRACTOR
78PCPMCMG0601	34888	78PLGG06	เปลี่ยนจารบี Coupling Gear (Shell GADUS	7.00	22/07/2022	22/07/2022	7788P1-CR1-BP-GCO1217	E/07810BE-3040560	CYCLO DRIVE OF HOPPER SCREW NO.4
78PCPMCMG0601	34886	78PLGP06	เปลี่ยนจารบี COUPLING PUMP (Shell GADUS	7.00	22/07/2022	22/07/2022	7788P1-CR1-BP-GCO1217	E/07810BE-3040560	CYCLO DRIVE OF HOPPER SCREW NO.4
78PCPMCMG0601	34883	78PMCMG06	ตรวจสภาพน้ำมัน Gear (Omala S4 GX)	7.00	22/07/2022	22/07/2022	7788P1-CR1-BP-CO1206	E/07810BP-1110080	LIVE BIN FEED CONVEYOR
78PCPMCMG0601	34887	78PMCMG06	ตรวจสภาพ Chain,Bush,Coupling,Flight	7.00	22/07/2022	22/07/2022	7788P1-CR1-BP-GCO1217	E/07810BE-3040560	CYCLO DRIVE OF HOPPER SCREW NO.4
78PCPMCMG0602	34889	78PMCMG06	ตรวจสภาพ Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-BP-GCO1217	E/07810BE-3040560	CYCLO DRIVE OF HOPPER SCREW NO.4

78PR1MM1201	34967	78PMMA06	ตัวกรอง AGI	7.00	22/07/2022	22/07/2022	7788P1-CR1-RE-AG813	E707810R1-0300200	LIME MUD STORAGE AGITATOR
78PR1MM0601	34970	78PMIM06	ตัวกรอง Bush Bearing, Belt, Chain	7.00	22/07/2022	22/07/2022	7788P1-CR1-RE-CO808	E707810R1-1100210	LIME CRUSHER CONVEYOR
78PR1MM0601	34978	78PMIM06	ตัวกรอง Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-RE-GC0808	E707810R1-3020090	RED GEAR OF LIME CRUSHER CONV.
78PR1MM0601	34977	78PMMP06	ตัวกรอง Bolt & Rubber Coupling Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-RE-GN010	E707810R1-2200140	JET CLEANER PUMP
78PRBCN0601	35013	78PCNP06	เปลี่ยน Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-PU032	E707810R0-2000610	AMMONIA PUMP NO.1
78PRBCN0602	35011	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-PU032	E707810R0-2000610	AMMONIA PUMP NO.1
78PRBLG00101	36259	78PLGC01	ตัวกรอง Bush Bearing, Belt, Chain	41.00	22/07/2022	22/07/2022	7788P1-CR1-RB-RF350	E707810R0-0720040	ASH HOPPER ROTARY FEEDER
78PRBLG00101	36301	78PLGG01	ตัวกรอง Coupling Gear (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-RB-GCSB203	E707810R0-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PRBLG00601	35020	78PLGG06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-GCSB203	E707810R0-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PRBLG00101	36260	78PLGP01	ตัวกรอง COUPLING PUMP (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-RB-PU032	E707810R0-2000610	AMMONIA PUMP NO.1
78PRBLG00601	35014	78PLGP06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-PU032	E707810R0-2000610	AMMONIA PUMP NO.1
78PRBLG00601	35018	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-GCSB203	E707810R0-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PRBLG00601	35012	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-PU032	E707810R0-2000610	AMMONIA PUMP NO.1
78PRBMN0601	35008	78PMIM06	ตัวกรอง Bush Bearing, Belt, Chain	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-RF350	E707810R0-0720040	ASH HOPPER ROTARY FEEDER
78PRBMN0601	35005	78PMME06	ตัวกรอง Condenser, Evaporator, Cooler	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-HF500	E707810R0-0230080	SMELT SPOUT COOLER
78PRBMN0601	35019	78PMIM06	ตัวกรอง Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-GCSB203	E707810R0-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PRBMN0602	35021	78PMIM06	ตัวกรอง Bolt & Rubber Coupling Gear	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-GCSB203	E707810R0-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PRBMN0601	35016	78PMMP06	ตัวกรอง Bolt & Rubber Coupling Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-RB-PU032	E707810R0-2000610	AMMONIA PUMP NO.1
78PRMLG00101	36273	78PLGP01	ตัวกรอง COUPLING PUMP (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-RM-PU020	E707810R0-2620990	STATIONARY ECO SUMP PUMP
78PTGCM0601	35039	78PCNP06	เปลี่ยน Packing Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-M2902	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PTGCM0602	35036	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-M2901	E707810TG-2100160	TURBINE MAIN OIL GEAR PUMP
78PTGLG00101	36304	78PLGG01	ตัวกรอง Coupling Gear (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	RED GEAR OF TURBO GENERATOR
78PTGLG00602	35045	78PLGG06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	RED GEAR OF TURBO GENERATOR
78PTGLG00101	36303	78PLGP01	ตัวกรอง COUPLING PUMP (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-TG-M2902	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PTGLG00601	35040	78PLGP06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	TURBINE AUXILIARY OIL PUMP
78PTGLG00602	35043	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-M2902	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PTGLG00601	35037	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-M2902	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PTGMM0601	35032	78PMME06	ตัวกรอง Condenser, Evaporator, Cooler	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-M0301	E707810TG-0200050	GLAND STEAM CONDENSER
78PTGMM0602	35044	78PMIM06	ตัวกรอง Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	RED GEAR OF TURBO GENERATOR
78PTGMM0603	35046	78PMIM06	ตัวกรอง Bolt & Rubber Coupling Gear	7.00	22/07/2022	22/07/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	RED GEAR OF TURBO GENERATOR
78PTGMM0601	35038	78PMMP06	ตัวกรอง Bolt & Rubber Coupling Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	TURBINE AUXILIARY OIL PUMP
78PUBCN0602	34923	78PCNP06	เปลี่ยน Packing Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1601	E707810UB-2100350	SAQ LOADING PUMP
78PUBCN0601	34898	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-M14074	E707810UB-1530100	TOP SEPARATOR OIL COOLING UNIT PUMP
78PUBCN0602	34899	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	HYDRAULIC UNIT TANK NO.2
78PUBCN0603	34920	78PCNS06	เปลี่ยน Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1601	E707810UB-2100350	SAQ LOADING PUMP
78PUBLG00101	36286	78PLGC01	ตัวกรอง Bush Bearing, Belt, Chain	41.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-CO1408	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP
78PUBLG00102	36289	78PLGC01	ตัวกรอง Chain, Bush, Coupling, Flight	41.00	22/07/2022	22/07/2022	7788P1-CR1-UB-AG1601	E707810UB-0301450	G2 BLOW TANK AGITATOR
78PUBLG00101	36288	78PLGG01	ตัวกรอง Coupling Gear (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBLG00102	36291	78PLGG01	ตัวกรอง Coupling Gear (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-UB-GC01602	E707810UB-3020560	RED GEAR OF CHIP METER
78PUBLG00601	34910	78PLGG06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBLG00602	34930	78PLGG06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-GC01602	E707810UB-3020560	RED GEAR OF CHIP METER
78PUBLG00101	36287	78PLGP01	ตัวกรอง COUPLING PUMP (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	SAQ LOADING PUMP
78PUBLG00102	36290	78PLGP01	ตัวกรอง COUPLING PUMP (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1601	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP
78PUBLG00601	34904	78PLGP06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	SAQ LOADING PUMP
78PUBLG00602	34924	78PLGP06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBLG00601	34908	78PLGP06	เปลี่ยน Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-GC01602	E707810UB-3020560	RED GEAR OF CHIP METER
78PUBLG00602	34928	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	SAQ LOADING PUMP
78PUBLG00602	34902	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1601	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP
78PUBLG00602	34922	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-M14074	E707810UB-1530100	HYDRAULIC UNIT TANK NO.2
78PUBLG00601	34901	78PLGP06	ตัวกรอง Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-CO1408	E707810UB-1120600	SCREW DILUTION PRESS NO.2
78PUBMM0601	34895	78PMIM06	ตัวกรอง Bush Bearing, Belt, Chain	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-AG1601	E707810UB-0301450	G2 BLOW TANK AGITATOR
78PUBMM0602	34913	78PMIM06	ตัวกรอง Chain, Bush, Coupling, Flight	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBMM0601	34909	78PMIM06	ตัวกรอง Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBMM0602	34911	78PMIM06	ตัวกรอง Bolt & Rubber Coupling Gear	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBMM0603	34929	78PMIM06	ตัวกรอง Pulley & V-Belt	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-GC01602	E707810UB-3020560	RED GEAR OF CHIP METER
78PUBMM0604	34931	78PMIM06	ตัวกรอง Bolt & Rubber Coupling Gear	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-GC01602	E707810UB-3020560	RED GEAR OF CHIP METER
78PUBMM0601	34906	78PMMP06	ตัวกรอง Bolt & Rubber Coupling Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	SAQ LOADING PUMP

78PUBMMHP0602	34926	78PMMMP03	အော့ကစာရ Bolt & Rubber Coupling Pump	10.00	22/07/2022	22/07/2022	7788P1-CR1-UB-OP1601	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP
78PWTMCPNP0601	35028	78PCNP06	ပေါက်စုံ Packing Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-WT-PU029-1B	E707810WT-2000070	METERING PUMP 1B FOR HCL
78PWTMCSN0602	35025	78PCNS06	ပေါက်စုံ Oil Cooler , Filter	7.00	22/07/2022	22/07/2022	7788P1-CR1-WT-PU029-1B	E707810WT-2000070	METERING PUMP 1B FOR HCL
78PWTLLGP0101	36302	78PLGP01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	41.00	22/07/2022	22/07/2022	7788P1-CR1-WT-PU029-1B	E707810WT-2000070	METERING PUMP 1B FOR HCL
78PWTLLGP0601	35029	78PLGP06	ပေါက်စုံကွပ်ကွပ် Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-WT-PU029-1B	E707810WT-2000070	METERING PUMP 1B FOR HCL
78PWTLLGP0601	35026	78PLGP06	အော့ကစာရကွပ်ကွပ် Coupling Pump (Shell GADUS S3)	7.00	22/07/2022	22/07/2022	7788P1-CR1-WT-M001	E707810IN-0230110	COOLER (HEAT EXCHANGER)
78PWTMMED0601	35024	78PMMME06	အော့ကစာရ Condenser,Evaporator,Cooler	7.00	22/07/2022	22/07/2022	7788P1-CR1-WT-M001	E707810IN-0230110	COOLER (HEAT EXCHANGER)
78PWTMMMP0601	35027	78PMMMP06	အော့ကစာရ Bolt & Rubber Coupling Pump	7.00	22/07/2022	22/07/2022	7788P1-CR1-WT-PU029-1B	E707810WT-2000070	METERING PUMP 1B FOR HCL
78PWTMMMS0301	29078	78PMMMS03	အော့ကစာရကွပ်ကွပ် Coupling Pump SEPARATOR	23.00	01/08/2022	01/08/2022	7788P1-CR1-EI-DSAP1	E707810EI-0130160	DEMIST SEPARATOR NO.1
78PBELGCG0101	36282	78PLGCG01	အံ့ကစာရ Chain,Bush,Coupling,Flight	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO1501	E707810BE-0060050	C-3SHREDDER CONVEYOR
78PBELGCG0101	36249	78PLGCG01	အံ့ကစာရ Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-GW1510	E707810BE-3040450	RED. GEAR OF EXTRACTOR
78PBELGCG0102	36251	78PLGCG01	အံ့ကစာရ Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-GD010	E707810BE-2602680	GEAR MOTOR OF CHLORINE AUTO DOOR
78PBELGPG0101	36248	78PLGPG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-PU1709C	E707810CI-2610930	PULP STORAGE RECIR. PUMP
78PBELGPG0102	36250	78PLGPG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-PU1531	E707810BE-2000710	NaOH METERING PUMP NO.1
78PBELGCG0101	36284	78PLGCG01	အံ့ကစာရ Chain,Bush,Coupling,Flight	42.00	22/08/2022	22/08/2022	7788P1-CR1-BP-CO1206	E707810BP-1110080	LIVE BIN FEED CONVEYOR
78PBELGCG0101	36285	78PLGCG01	အံ့ကစာရ Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BP-CO1217	E707810BE-3040550	CYCLE DRIVE OF HOPPER SCREW NO.4
78PCZLGG0101	36281	78PLGG01	အံ့ကစာရ Bush,Bearing,Belt,Chain	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-1100190	CO101 DRAG CHAIN CONVEYOR
78PCZLGG0101	36283	78PLGG01	အံ့ကစာရ Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3020440	MOUNTED GEAR M402-3 PRE-BREAKER SCREW 1G
78PCZLGP0101	36282	78PLGP01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3020440	SWL. METERING PUMP
78PCZLGR0101	36280	78PLGR01	အံ့ကစာရ Roller	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3020440	SWL. METERING PUMP
78PCZLGG0101	36276	78PLGG01	အံ့ကစာရ Chain,Bush,Coupling,Flight	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-0590190	ROLL. OF DEWATERING PRESS NO.3A
78PCZLGG0101	36275	78PLGG01	အံ့ကစာရ Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-0590190	RACK&CAR
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-BE-CO101	E707810CZ-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PCZLGG0101	36274	78PLGG01	အံ့ကစာရ COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08			

78PRMLGP0101	36273	78PLGP01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-TG-GM3123	E707810RM-2620990	STATIONARY ECO SUMP PUMP
78PTGLGG0101	36304	78PLGG01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	RED GEAR OF TURBO GENERATOR
78PTGLGP0101	36303	78PLGP01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-TG-M2902	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PUBLGC0101	36286	78PLGC01	အိတ်ကတ် Bush, Bearing, Belt, Chain	42.00	22/08/2022	22/08/2022	7788P1-CR1-UB-ODL-CO1408	E707810UB-1120600	SCREW DILUTION PRESS NO.2
78PUBLGG0102	36289	78PLGG01	အိတ်ကတ် Chain, Bush, Coupling, Flight	42.00	22/08/2022	22/08/2022	7788P1-CR1-UB-AG1601	E707810UB-0301450	G2 BLOW TANK AGITATOR
78PUBLGG0101	36288	78PLGG01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBLGG0102	36291	78PLGG01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-UB-GCO1602	E707810UB-3020560	RED. GEAR OF CHIP METER
78PUBLGG0101	36287	78PLGG01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	SAQ LOADING PUMP
78PUBLGG0102	36290	78PLGG01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-UB-OP1601	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP
78PUBLGG0101	36292	78PLGG01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	42.00	22/08/2022	22/08/2022	7788P1-CR1-WT-PU029-1B	E707810WT-2000070	METERING PUMP 1B FOR HCL
78PBLGG0101	36302	78PLGC01	အိတ်ကတ် Chain, Bush, Coupling, Flight	43.00	22/09/2022	22/09/2022	7788P1-CR1-BE-CO1501	E707810BE-0060060	C-SHREDDER CONVEYOR
78PBLGG0101	36249	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-BE-GM1510	E707810BE-3040450	RED. GEAR OF EXTRACTOR
78PBLGG0102	36251	78PLGG01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-BE-GD0110	E707810BE-6002680	RED. GEAR OF CHLORINE AUTO DOOR
78PBLGG0102	36248	78PLGG01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-BE-PU1709C	E707810C1-2610930	PULP STORAGE RECIR. PUMP
78PBLGG0101	36250	78PLGG01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-BE-PU1531	E707810BP-1110080	LIVE BIN FEED CONVEYOR
78PBLGG0101	36284	78PLGG01	အိတ်ကတ် Chain, Bush, Coupling, Flight	43.00	22/09/2022	22/09/2022	7788P1-CR1-BP-GCO1217	E707810BE-3040560	CYCLO DRIVE OF HOPPER SCREW NO.4
78PBLGG0101	36285	78PLGG01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-BP-CO1010	E707810C2-1100190	CO101 DRAG CHAIN CONVEYOR
78PBLGG0101	36281	78PLGG01	အိတ်ကတ် Bush, Bearing, Belt, Chain	43.00	22/09/2022	22/09/2022	7788P1-CM2-GM402-3	E707810C2-3020440	MOUNTED GEAR M402-3 PRE-BREAKER SCREW 1G
78PBLGG0101	36283	78PLGG01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CM2-PU729	E707810C2-2000800	SWL. METERING PUMP
78PBLGG0101	36280	78PLGG01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CM2-M4081	E707810C2-0590190	ROLL OF DEWATERING PRESS NO.3A
78PBLGG0101	36282	78PLGG01	အိတ်ကတ် Roller	43.00	22/09/2022	22/09/2022	7788P1-CM2-REF-M404-2	E707810C2-0040300	REFINER
78PBLGG0101	34843	78PMS02	ကုတ်ကတ် Strainer Mech Seal	22.00	22/09/2022	22/09/2022	7788P1-CM2-REF-M404-2	E707810C2-0040300	REFINER
78PBLGG0101	36276	78PLGC01	အိတ်ကတ် Chain, Bush, Coupling, Flight	43.00	22/09/2022	22/09/2022	7788P1-RM-CP-M6005	E707810CP-1010230	RACKCAR
78PBLGG0101	36275	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-RM-CP-GCO3016	E707810CP-3041470	RED.GEAR OF BELT CHIPPER NO.7
78PBLGG0101	36274	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-RM-CP-PU0010	E707810CP-2100290	OIL PUMP OF GRINDING MACHINE
78PBLGG0101	36277	78PLGC01	အိတ်ကတ် Bush Roll, Bearing, Belt, Chain	37.00	22/09/2022	22/09/2022	7788P1-1-SLG	E70780A-050-8290	DRIVE ROLL
78PBLGG0101	36258	78PLGC01	အိတ်ကတ် Bush, Bearing, Belt, Chain	37.00	22/09/2022	22/09/2022	7788P1-1-DPB-E2530	E70780A-073-7010	SCREW THICKENING Disc.1
78PBLGG0101	36259	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	37.00	22/09/2022	22/09/2022	7788P1-1-FTL-P2380	E70780A-304-7010	DEAERATION FOAM PUMP GEAR BOX
78PBLGG0101	36255	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-E1-GFA001	E707810E1-3040760	RED.GEAR OF COOLING TOWER FAN NO.1
78PBLGG0101	36258	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-E1-PU925	E707810E1-2610040	ACID PUMP
78PBLGG0101	36279	78PLGC01	အိတ်ကတ် Bush, Bearing, Belt, Chain	43.00	22/09/2022	22/09/2022	7788P1-CR1-E2-GFA001	E707810E2-3041020	RED.GEAR OF COOLING TOWER FAN NO.1
78PBLGG0101	36277	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-E2-PU605	E707810E2-2600160	STRONG BLACK LIQUOR PUMP NO.1
78PBLGG0101	36279	78PLGC01	အိတ်ကတ် Bush, Bearing, Belt, Chain	43.00	22/09/2022	22/09/2022	7788P1-CR1-PM-M1658-T1	E707810PM-0520010	HDP.NO.2 FELT TOP ROLL NO.1
78PBLGG0101	36277	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-PM-M1604	E707810PM-3040410	RED.GEAR OF ROTARY KNIFE CUTTER
78PBLGG0101	36252	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-PM-M1605	E707810PM-2100080	TABLE LIFT HYDRAULIC PUMP
78PBLGG0101	36254	78PLGC01	အိတ်ကတ် Bush, Bearing, Belt, Chain	43.00	22/09/2022	22/09/2022	7788P1-CR1-RE-CO808	E707810R1-1100210	LIME CRUSHER CONVEYOR
78PBLGG0101	36253	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-RE-GN010	E707810R1-3020090	RED.GEAR OF LIME CRUSHER CONV.
78PBLGG0101	36259	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-RE-GN010	E707810R1-2200140	JET CLEANER PUMP
78PBLGG0101	36301	78PLGC01	အိတ်ကတ် Bush, Bearing, Belt, Chain	43.00	22/09/2022	22/09/2022	7788P1-CR1-RB-RF350	E707810RB-0720040	ASH HOPPER ROTARY FEEDER
78PBLGG0101	36273	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-RB-GCSB203	E707810RB-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PBLGG0101	36304	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-RB-PU032	E707810RB-2000610	AMMONIA PUMP NO.1
78PBLGG0101	36303	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-RB-PU029	E707810RB-2620990	STATIONARY ECO SUMP PUMP
78PBLGG0101	36286	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	RED.GEAR OF TURBO GENERATOR
78PBLGG0101	36287	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-TG-M2902	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PBLGG0101	36288	78PLGC01	အိတ်ကတ် Bush, Bearing, Belt, Chain	43.00	22/09/2022	22/09/2022	7788P1-CR1-UB-AG1601	E707810UB-0301450	SCREW DILUTION PRESS NO.2
78PBLGG0101	36291	78PLGC01	အိတ်ကတ် Chain, Bush, Coupling, Flight	43.00	22/09/2022	22/09/2022	7788P1-CR1-UB-ODL-GM14073	E707810UB-3020540	G2 BLOW TANK AGITATOR
78PBLGG0101	36287	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-UB-GCO1602	E707810UB-3020560	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PBLGG0101	36290	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-UB-PU1444	E707810UB-2000600	SAQ LOADING PUMP
78PBLGG0101	36302	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	43.00	22/09/2022	22/09/2022	7788P1-CR1-UB-OP1601	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP
78PBLGG0101	29058	78PLO03	CHANGE OIL TELLUS 68 S LITE	23.00	22/09/2022	22/09/2022	7788P1-CR1-WT-PU029-1B	E707810WT-2000070	METERING PUMP 1B FOR HCL
78PBLGG0101	36292	78PLGC01	အိတ်ကတ် Chain, Bush, Coupling, Flight	44.00	22/10/2022	22/10/2022	7788P1-CR1-E1-T901	E707810E1-1510440	W.B.L. TANK NO.1
78PBLGG0101	36249	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-BE-CO1501	E707810BE-0060060	C-SHREDDER CONVEYOR
78PBLGG0101	36251	78PLGC01	အိတ်ကတ် Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-BE-GD0110	E707810BE-3040450	RED. GEAR OF EXTRACTOR
78PBLGG0101	36248	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-BE-PU1709C	E707810C1-2610930	PULP STORAGE RECIR. PUMP
78PBLGG0101	36250	78PLGC01	အိတ်ကတ် COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-BE-PU1531	E707810BP-1110080	NaOH METERING PUMP NO.1
78PBLGG0101	36284	78PLGC01	အိတ်ကတ် Chain, Bush, Coupling, Flight	44.00	22/10/2022	22/10/2022	7788P1-CR1-BP-CO1206	E707810BP-1110080	LIVE BIN FEED CONVEYOR

78PRLGG0101	36285	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CP1-BP-GC01217	E707810BE-3040560	CYCLO DRIVE OF HOPPER SCREW NO.4
78PRLGG0101	36281	78PLGG01	شفتارت	Bush, Bearing, Belt, Chain	44.00	22/10/2022	22/10/2022	7788P1-CM2-CO101	E707810C2-1100190	CO101 DRAG CHAIN CONVEYOR
78PRLGG0101	36283	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CM2-GM402-3	E707810C2-3020440	MOUNTED GEAR M402-3 PRE-BREAKER SCREW 1G
78PRLGG0101	36282	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CM2-PU729	E707810C2-2000800	SWL METRING PUMP
78PRLGG0101	36280	78PLGG01	شفتارت	Roller	44.00	22/10/2022	22/10/2022	7788P1-CM2-M4081	E707810C2-0590190	ROLL OF DEWATERING PRESS NO.3A
78PRLGG0101	36276	78PLGG01	شفتارت	Chain, Bush, Coupling, Flight	44.00	22/10/2022	22/10/2022	7788P1-RM-CP-M6005	E707810CP-1010230	RACK CAR
78PRLGG0101	36275	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-RM-CP-GC03016	E707810CP-3041470	RED GEAR OF BELT CHIPPER NO.7
78PRLGG0101	36274	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-RM-CP-PU0010	E707810CP-2100290	OIL PUMP OF GRINDING MACHINE
78PRLGG0101	36637	78PLGG01	شفتارت	Bush Roll, Bearing, Belt, Chain	38.00	22/10/2022	22/10/2022	7788P1-1-SLG	E70780A-050-8290	DRIVE ROLL
78PRLGG0102	39638	78PLGG01	شفتارت	Bush, Bearing, Belt, Chain	38.00	22/10/2022	22/10/2022	7788P1-1-DPB-E2530	E70780A-073-7010	SCREW THICKENING Disc.1
78PRLGG0101	39640	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	38.00	22/10/2022	22/10/2022	7788P1-1-FT1-P2380	E70780A-304-7010	DEAERATION FOAM PUMP GEAR BOX
78PRLGG0101	36256	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-E1-GFA001	E707810E1-3040760	RED.GEAR OF COOLING TOWER FAN NO.1
78PRLGG0101	36255	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-E1-PU925	E707810E1-2610040	ACID PUMP
78PRLGG0101	36258	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-E2-GFA001	E707810E2-3041020	RED.GEAR OF COOLING TOWER FAN NO.1
78PRLGG0101	36257	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-E2-PU605	E707810E2-2600160	STRONG BLACK LIQUOR PUMP NO.1
78PRLGG0101	36279	78PLGG01	شفتارت	Bush, Bearing, Belt, Chain	44.00	22/10/2022	22/10/2022	7788P1-CP1-PM-M1658-T1	E707810PM-0520010	HDP NO.2 FELT TOP ROLL NO.1
78PRLGG0101	36277	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CP1-PM-GM1604	E707810PM-3040410	RED.GEAR OF ROTARY KNIFE CUTTER
78PRLGG0101	36278	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CP1-PM-M1605	E707810PM-2100080	TABLE LIFT HYDRAULIC PUMP
78PRLGG0105	36252	78PLGG01	شفتارت	Bush, Bearing, Belt, Chain	44.00	22/10/2022	22/10/2022	7788P1-CR1-RE-CO808	E707810R1-1100210	LIME CRUSHER CONVEYOR
78PRLGG0101	36254	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-RE-GC0808	E707810R1-3020090	RED.GEAR OF LIME CRUSHER CONV.
78PRLGG0101	36253	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-RE-GN010	E707810R1-2200140	JET CLEANER PUMP
78PRLGG0101	36259	78PLGG01	شفتارت	Bush, Bearing, Belt, Chain	44.00	22/10/2022	22/10/2022	7788P1-CR1-RB-RT350	E707810RB-0720040	ASH HOPPER ROTARY FEEDER
78PRLGG0101	36301	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-RB-GCSB203	E707810RB-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PRLGG0101	36260	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-RB-PU032	E707810RB-2600060	AMMONIA PUMP NO.1
78PRLGG0101	36273	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-RM-PU020	E707810RM-2620090	STATIONARY ECO SUMP PUMP
78PRLGG0101	36304	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-TG-GM3123	E707810TG-3070110	RED.GEAR OF TURBO GENERATOR
78PRLGG0101	36303	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CR1-TG-M2902	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PRLGG0101	36286	78PLGG01	شفتارت	Bush, Bearing, Belt, Chain	44.00	22/10/2022	22/10/2022	7788P1-CP1-UB-ODL-CO1408	E707810UB-1120600	SCREW DILUTION PRESS NO.2
78PRLGG0101	36289	78PLGG01	شفتارت	Chain, Bush, Coupling, Flight	44.00	22/10/2022	22/10/2022	7788P1-CP1-UB-AG1601	E707810UB-0301450	G2 BLOW TANK AGITATOR
78PRLGG0102	36288	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CP1-UB-ODL-GM14073	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PRLGG0101	36291	78PLGG01	شفتارت	Coupling Gear (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CP1-UB-GC01602	E707810UB-3020560	RED. GEAR OF CHIP METER
78PRLGG0101	36287	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CP1-UB-PU1444	E707810UB-2000600	SAO LOADING PUMP
78PRLGG0102	36290	78PLGG01	شفتارت	COUPLING PUMP (Shell GADUS S3)	44.00	22/10/2022	22/10/2022	7788P1-CP1-UB-OP1601	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP
78PUBMMP0602	34926	78PMP03	شفتارت	Bolt & Rubber Coupling Pump	11.00	22/10/2022	22/10/2022	7788P1-CP1-UB-OP1601	E707810UB-2100350	TOP SEPARATOR OIL COOLING UNIT PUMP

78PDLGC0102	39638	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	40.00	22/12/2022	78PDLGC01-1-DPB-E2530	E70780A-073-7010	SCREW THICKENING Disc.1
78PDLGC0101	39640	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	40.00	22/12/2022	78PDLGC01-1-FT1-P2380	E70780A-304-7010	DEAERATION FOAM PUMP GEAR BOX
78PEILGC0101	36256	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PEILGC01-1-E1-GFA001	E707810E1-3040760	RED.GEAR OF COOLING TOWER FAN NO.1
78PEILGC0101	36255	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PEILGC01-1-E1-PJ925	E707810E1-2610040	ACID PUMP
78PEZLGC0101	36258	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PEZLGC01-1-E2-GFA001	E707810E2-3041020	RED.GEAR OF COOLING TOWER FAN NO.1
78PEZLGC0101	36257	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PEZLGC01-1-E2-PJ605	E707810E2-2600160	STRONG BLACK LIQUOR PUMP NO.1
78PPMLGC0101	36279	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PPMLGC01-1-PM-M1658-T1	E707810PM-0520010	HDP.NO.2 FELT TOP ROLL NO.1
78PPMLGC0101	36277	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PPMLGC01-1-PM-M1605	E707810PM-3040410	RED.GEAR OF ROTARY KNIFE CUTTER
78PPMLGC0105	36278	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PPMLGC01-1-RE-M1605	E707810PM-2100080	TABLE LIFT HYDRAULIC PUMP
78PRILGC0101	36254	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PRILGC01-1-RE-M1605	E707810R1-1100210	LIME CRUSHER CONVEYOR
78PRILGC0101	36253	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PRILGC01-1-RE-M1605	E707810R1-3020090	RED.GEAR OF LIME CRUSHER CONV.
78PRBLGC0101	36259	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PRBLGC01-1-RE-M1605	E707810R1-2200140	JET CLEANER PUMP
78PRBLGC0101	36301	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PRBLGC01-1-RE-M1605	E707810R1-2200140	ASH HOPPER ROTARY FEEDER
78PRBLGC0101	36260	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PRBLGC01-1-RE-M1605	E707810R1-3020320	GEAR CARRIAGE OF SOOT BLOWER NO.3
78PRBLGC0101	36273	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PRBLGC01-1-RE-M1605	E707810R1-2000610	AMMONIA PUMP NO.1
78PTGLGC0101	36304	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PTGLGC01-1-RE-M1605	E707810RM-2620990	STATIONARY ECO SUMP PUMP
78PTGLGC0101	36303	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PTGLGC01-1-RE-M1605	E707810TG-3070110	RED.GEAR OF TURBO GENERATOR
78PUBLGC0101	36286	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PUBLGC01-1-RE-M1605	E707810TG-2300030	TURBINE AUXILIARY OIL PUMP
78PUBLGC0102	36289	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PUBLGC01-1-RE-M1605	E707810UB-1120600	SCREW DILUTION PRESS NO.2
78PUBLGC0101	36288	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PUBLGC01-1-RE-M1605	E707810UB-0301450	G2 BLOW TANK AGITATOR
78PUBLGC0102	36291	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PUBLGC01-1-RE-M1605	E707810UB-3020540	MOUNTED GEAR SHREDDER REPULPER - PRESS#2
78PUBLGC0101	36287	78PLGC01	สัณฐาน	สัณฐาน	22/12/2022	22/12/2022	46.00	22/12/2022	78PUBLGC01-1-RE-M1605	E707810UB-3020560	RED. GEAR OF CHIP METER
										E707810UB-2000600	SAO LOADING PUMP

เอกสารแนบที่ 2.28

ผลการตรวจวัดความเข้มของแสง ประจำปี 2565



Industrial Service and Lab
SCIECO Services Company Limited
33/2 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.scieco.co.th E-Mail: environmentalmk@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
1.		502	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
2.		524	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
3.		569	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
4.		413	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
5.		504	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

หมายเหตุ :

- ค่ามาตรฐานที่ใช้จากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
- วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)



Industrial Service and Lab
SCIECO Services Company Limited
33/2 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.scieco.co.th E-Mail: environmentalmk@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
6.		527	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
7.		413	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
8.		414	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
9.		687	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
10.		701	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

หมายเหตุ :

- ค่ามาตรฐานที่ใช้จากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
- วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)



Industrial Service and Lab
SCIECO Services Company Limited
332 Moo 3, Bampa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.scieco.co.th E-Mail: environmentalmk@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บบ้านโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงบุรี อ.ท่าเสา จ.พิจิตร 36110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
11.		725	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
12.		774	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
13.		608	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
14.		592	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

หมายเหตุ
I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วิเคราะห์ที่ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้ระบุเหตุผล
Page 3 of 39



Industrial Service and Lab
SCIECO Services Company Limited
332 Moo 3, Bampa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
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www.scieco.co.th E-Mail: environmentalmk@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บบ้านโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงบุรี อ.ท่าเสา จ.พิจิตร 36110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
15.		423	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
16.		593	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
17.		416	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
18.		579	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
19.		494	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

หมายเหตุ
I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วิเคราะห์ที่ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการ

ห้ามคัดค้านรายงานผลการ



Industrial Service and Lab
SCIECO Services Company Limited
332 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone :+66 (0) 3627 3099 Fax :+66 (0) 3627 3100
Calibration Telephone :+66 (0) 3627 3096 Fax :+66 (0) 3627 3100
www.scieco.co.th E-Mail: environmentalmk@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บมันโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงบุรี อ.ท่าเสา อ.มันโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
20.		556	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
21.		484	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
22.		680	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
23.		665	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
24.		528	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

หมายเหตุ :
I. ค่ามาตรฐานที่ใช้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561
II. วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจาก
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บมันโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงบุรี อ.ท่าเสา อ.มันโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
25.		418	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
26.		661	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
27.		717	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
28.		449	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
29.		403	-	≥ 300 - 400	งานละเอียดเล็กน้อย

หมายเหตุ :
I. ค่ามาตรฐานที่ใช้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561
II. วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		686	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		474	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		502	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		415	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		425	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วัดค่าที่ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันที่ทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการตรวจ

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		438	-	≥ 300 - 400	งานละเอียดเล็กน้อย (งานที่ขึ้นงานขึ้นจากสำนักงาน สาขามอกลงในใต้ และมีความแตกต่างของสีเล็กน้อย)
		520	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		524	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		346	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		257	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		331	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานที่ขึ้นงานขึ้นจากสำนักงาน สาขามอกลงในใต้ และมีความแตกต่างของสีเล็กน้อย)

หมายเหตุ :
I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วัดค่าที่ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันที่ทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.
- * แสงสว่างไม่เพียงพอ

(รับรองเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการตรวจ

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		410	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		411	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		677	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		938	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		913	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		312	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)

หมายเหตุ :
I. ค่ามาตรฐานที่ใช้จากประกาศกระทรวงแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วิเคราะห์ภาคสนาม

- ตรวจวัดโดย Lux Meter รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันที่ทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.
- * แสงสว่างไม่เพียงพอ

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

หน้าคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจาก
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		239	-	≥ 200 - 300	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		100	-	≥ 200 - 300	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		312	-	≥ 200 - 300	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		557	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		412	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)
		467	-	≥ 400 - 500	งานเย็บเสื้อผ้า (งานประจำในสำนักงาน)

II. วิเคราะห์ภาคสนาม

- ตรวจวัดโดย Lux Meter รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันที่ทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.
- * แสงสว่างไม่เพียงพอ

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเยื่อมันโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงสุโขทัย อ.มันโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		445	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		456	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		514	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

หมายเหตุ :

- ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
- วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

ห้ามคัดลอกหรือเผยแพร่ผลการวิเคราะห์/ทดสอบนี้เด็ดขาดโดยไม่ได้รับอนุญาตจาก
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Industrial Service and Lab
SCIECO Services Company Limited
332 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.scieco.co.th E-Mail: environmentalmk@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเยื่อมันโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงสุโขทัย อ.มันโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		750	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		445	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		582	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		554	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		429	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

หมายเหตุ :

- ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
- วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

ห้ามคัดลอกหรือเผยแพร่ผลการวิเคราะห์/ทดสอบนี้เด็ดขาดโดยไม่ได้รับอนุญาตจาก
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SCIECO Services Company Limited
33/2 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.scieco.co.th E-Mail: environmentalmkt@scg.com, calibrate@scg.com



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท แลติทิมทีเคเคเคไทย จำกัด (โรงงานโม่)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		530	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		401	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		401	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		445	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		425	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

- I. ค่ามาตรฐานที่ใช้จากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความปลอดภัยแสงสว่าง พ.ศ. 2561
II. วิธีการที่ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : 0653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจากห้อง

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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท แลติทิมทีเคเคเคไทย จำกัด (โรงงานโม่)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		400	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		426	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		412	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		402	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

- I. ค่ามาตรฐานที่ใช้จากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความปลอดภัยแสงสว่าง พ.ศ. 2561
II. วิธีการที่ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : 0653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจากห้อง

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SCIECO Services Company Limited
332 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเยื่อป่านโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงสุโขทัย อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		416	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)
		551	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานประจำในสำนักงาน)

และคู่มือแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561

- II. วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต
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Industrial Service and Lab
SCIECO Services Company Limited
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเยื่อป่านโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงสุโขทัย อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

ลำดับที่	ตำแหน่งจุดตรวจวัด	ผลการตรวจวัด (Lux)		ค่ามาตรฐาน ¹ (Lux)	ความละเอียดของงาน
		กลางวัน	กลางคืน		
		992	-	≥ 200 - 300	งานเบา (งานที่งานเขียนตัวใหญ่สามารถมองเห็นได้อย่างชัดเจน มีความละเอียดของสีปานกลาง)
		922	-	≥ 200 - 300	งานเบา (งานที่งานเขียนตัวใหญ่สามารถมองเห็นได้อย่างชัดเจน มีความละเอียดของสีปานกลาง)
		986	-	≥ 400 - 500	งานละเอียดเล็กน้อย (งานที่งานเขียนตัวปานกลางมองเห็นได้อย่างชัดเจน มีความละเอียดของสีปานกลาง)
		872	-	≥ 200 - 300	งานเบา (งานที่งานเขียนตัวใหญ่สามารถมองเห็นได้อย่างชัดเจน มีความละเอียดของสีปานกลาง)

หมายเหตุ :

- I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต
Page 17 of 39



รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน			
สำนักงานส่วนเครื่องปั้นดินเผา (ด้านหลังที่ 2)				
P-1	249		Lux	
P-2	318		Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง	284		Lux	บริเวณอาคาร/พื้นที่
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	$\geq 100^{I}$		Lux	บริเวณพื้นที่ทั่วไปที่มีการใช้รถของบุคคลและ/หรือยานพาหนะในภาวะปกติ (ภายในอาคาร)
ค่ามาตรฐานค่าเฉลี่ยแสงสว่างค่าขีด	$\geq 50^{I}$		Lux	

หมายเหตุ :

- I. ค่ามาตรฐานที่นำมาใช้ประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความปลอดภัยในการทำงาน พ.ศ.2561
- II. วิธีการทดสอบ
 - ค่าวัดโดย Lux Meter คือ : EXTECH Instrument ที่ : 407026 หมายเลขเครื่อง : Q653830
 - ดำเนินทำการตรวจสอบระหว่างเวลา 10:00 น. - 16:30 น.

(ผู้ทรงคุณวุฒิเฉพาะด้าน/ผู้เชี่ยวชาญ/หรืออาสาสมัคร)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์สภาพการทำงาน

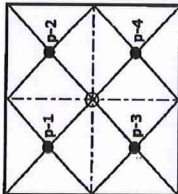
ห้ามคัดถ่ายรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้ขออนุมัติ

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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

รายงาน/บริษัท
ชื่อ
วันที่ตรวจวัด
เลขที่ตัวอย่าง
ผลการตรวจ/ทดสอบ

Report No. AA 22/0498

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน			
สำนักงานส่วนผลิตชิ้นส่วน ห้องแม่ข่าย	p-1	493	Lux	<div></div> <div>แสงเฉลี่ย = $p1 + p2 + p3 + p4$ 4</div> <div>p = ค่าเฉลี่ยของ p ทั้ง 4 จุด</div>
	p-2	491	Lux	
	p-3	362	Lux	
	p-4	371	Lux	
ผลการตรวจวัดค่าแสงในแสงสว่าง	429		Lux	ประเภทอาคาร/พื้นที่
ค่ามาตรฐานค่าแสงในแสงสว่าง	$\geq 100^1$		Lux	บริเวณพื้นที่ใช้ประโยชน์ทั่วไป
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด	$\geq 50^1$		Lux	

หมายเหตุ:

- I. ค่ามาตรฐานนี้ไม่มาจากการศึกษาหรือการสังเกตการณ์เชิงพรรณนา เมื่อมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
- II. ในกรณีที่ขาดคน
- เครื่องวัด Lux Meter ยี่ห้อ : EXTECH Instrument จุ. : 407026 หมายเลขเครื่อง : Q653830
- ลงบันทึกกิจกรรมไว้ระหว่างเวลา 10:00 น. – 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์สภาพการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจากห้อง

Page 20 of 39

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท
บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บมันโง่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

Report No. AA 22/0498

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย
	กลางวัน		
สำนักงานส่วนผลิตชิ้นส่วนอากาศยานเดิม (ตำแหน่งที่ 1)	P-1	149	Lux
	P-2	120	Lux
	P-3	254	Lux
	P-4	110	Lux
	P-5	135	Lux
	P-6	102	Lux
	P-7	113	Lux
	P-8	150	Lux
	P-9	148	Lux
	P-10	108	Lux
ผลการตรวจวัดค่าแสงสีแสงสว่าง			
ค่ามาตรฐานค่าแสงสว่าง		139	Lux
ค่ามาตรฐานค่าแสงสว่าง		$\geq 100^1$	Lux
ค่ามาตรฐานค่าแสงสว่างต่ำสุด		$\geq 50^1$	Lux

หมายเหตุ:

I. คำมาตรฐานที่ใช้จากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความปลอดภัย พ.ศ.2561

II. วิธีการทดสอบ

- เครื่องวัด Lux Meter ยี่ห้อ : EXTECH Instrument จุ : 407026 หมายเลขเครื่อง : Q653830

- ดำเนินทำการทดสอบระหว่างเวลา 10:00 น. – 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์สภาพการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต

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SCIECO Services Company Limited
332 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

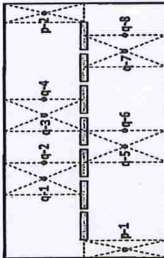
Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บบ้านโป่ง)
ที่อยู่ 19 หมู่ 19 อ.แสงซูด ต.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110

วันที่ตรวจวัด 27/08/65

เลขที่ตัวอย่าง AR22/21933

ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางแจ้ง			
สำนักงานส่วนผลิตชิ้นส่วน ห้องประชุมอิเล็กทรอนิกส์	p-1	446	Lux	
	p-2	472	Lux	
	q-1	497	Lux	
	q-2	307	Lux	
	q-3	203	Lux	
	q-4	534	Lux	
	q-5	620	Lux	
	q-6	441	Lux	
q-7	410	Lux	แสงเฉลี่ย = $\frac{Q(p-1)+p}{N}$ Q = ค่าเฉลี่ยของ q ทั้ง 8 จุด (คำนวณ ส่วนรวม) p = ค่าเฉลี่ยของ p ทั้ง 2 จุด (ส่วนห้อง) N = จำนวนหลอดไฟในแถว	
q-8	358	Lux		
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง				
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	424	Lux	ประเภทอาคาร/พื้นที่	
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	$\geq 300^1$	Lux	บริเวณพื้นที่ที่ไม่ใช่ประโยชน์ในสำนักงาน (ห้องประชุม)	
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด	$\geq 150^1$	Lux		

หมายเหตุ :

- คำนวณฐานที่ใช้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
- วิเคราะห์ใช้ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการปฏิบัติงาน

บันทึกคำขอร้องงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับมอบหมายจากห้อง



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

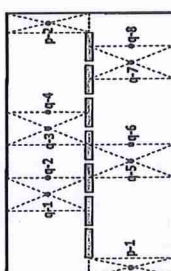
Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บบ้านโป่ง)
ที่อยู่ 19 หมู่ 19 อ.แสงซูด ต.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110

วันที่ตรวจวัด 27/08/65

เลขที่ตัวอย่าง AR22/21933

ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางแจ้ง			
สำนักงานส่วนผลิตชิ้นส่วน ห้องประชุม TPM				
p-1	466		Lux	
p-2	414		Lux	
q-1	303		Lux	
q-2	322		Lux	
q-3	390		Lux	
q-4	322		Lux	
q-5	329		Lux	
q-6	826		Lux	
q-7	810		Lux	
q-8	705		Lux	
				$\text{แสงเฉลี่ย} = \frac{Q(P-1)+P}{N}$ <p>Q = ค่าเฉลี่ยของ q ทั้ง 8 จุด (ค่าเฉลี่ย ส่วนรวม) P = ค่าเฉลี่ยของ p ทั้ง 2 จุด (ส่วนห้อง) N = จำนวนหลอดไฟในแถว</p>
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง				ประเภทอาคาร/พื้นที่
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง				บริเวณพื้นที่ที่ไม่ใช่ประโยชน์ในสำนักงาน
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด				(ห้องประชุม)
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด				

หมายเหตุ :

- คำนวณฐานที่ใช้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
- วิเคราะห์ใช้ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการปฏิบัติงาน

บันทึกคำขอร้องงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับมอบหมายจากห้อง



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บผ้าโป่ง)
ที่อยู่ 19 หมู่ 19 อ.แสงสุโขทัย จ.พิจิตร อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด	หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
สำนักงานส่วนผลิตชิ้นงาน โรงเย็บผ้า	กลางแจ้ง		
P-1	83	Lux	
P-2	105	Lux	
P-3	65	Lux	
P-4	104	Lux	
P-5	76	Lux	
P-6	67	Lux	

แผนผังตำแหน่งจุดวัดแสงสว่าง

แสงเฉลี่ย = $\frac{P_1 + P_2 + P_3 + P_4 + P_5 + P_6}{n}$
P = ค่าตรวจวัดแสงสว่างต่อ 2x2 ตารางเมตร
n = จำนวนของจุดตรวจวัด

หมายเหตุ :
I. ค่ามาตรฐานที่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561
II. ในตารางที่ภาคผนวก
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.
- * แสงสว่างไม่เพียงพอ

(รับรองผลเฉพาะค่าที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

บันทึกถ้อยคำรายงานผลการวิเคราะห์/ทดสอบนี้ใช้ได้เพียงบางส่วน โดยไม่ได้รับอนุญาตจาก
Page 24 of 39



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บผ้าโป่ง)
ที่อยู่ 19 หมู่ 19 อ.แสงสุโขทัย จ.พิจิตร อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด	หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
สำนักงานส่วนผลิตชิ้นงาน โรงเย็บผ้า	กลางแจ้ง		
P-1	290	Lux	
P-2	340	Lux	
P-3	344	Lux	
P-4	261	Lux	

แผนผังตำแหน่งจุดวัดแสงสว่าง

แสงเฉลี่ย = $\frac{P_1 + P_2 + P_3 + P_4}{n}$
P = ค่าเฉลี่ยของ P ทั้ง 4 จุด
n = 4

หมายเหตุ :
I. ค่ามาตรฐานที่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะค่าที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

บันทึกถ้อยคำรายงานผลการวิเคราะห์/ทดสอบนี้ใช้ได้เพียงบางส่วน โดยไม่ได้รับอนุญาตจาก
Page 25 of 39



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท สลิดภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ถ.แสงสุโขทัย ต.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
วันที่ออกรายงาน 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางแจ้ง		
สำนักงานส่วนผลิตชิ้นงาน ห้องประกอบหน้า			
P-1	503	Lux	<div>แสงเฉลี่ย = $\frac{10(N-1)+2}{N}$</div> <div>Q = ค่าเฉลี่ยของ q ทั้ง 8 จุด (ด้านข้าง ส่วนขวา)</div> <div>P = ค่าเฉลี่ยของ p ทั้ง 2 จุด (มุมห้อง)</div> <div>N = จำนวนหลอดไฟแนวนอน</div>
P-2	748	Lux	
Q-1	662	Lux	
Q-2	912	Lux	
Q-3	901	Lux	
Q-4	908	Lux	
Q-5	976	Lux	
Q-6	818	Lux	
Q-7	825	Lux	
Q-8	705	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง			ประเภทอาคาร/พื้นที่
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง			บริเวณพื้นที่ที่ไม่ใช่บริเวณ/ขอบในสำนักงาน
ค่ามาตรฐานจุด/แสงสว่างต่ำสุด			(ห้องประชุม)

หมายเหตุ :
I. ค่ามาตรฐานที่ใช้จากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

บันทึกคำขานงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับรอง
Page 26 of 39



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332 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท สลิดภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ถ.แสงสุโขทัย ต.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
วันที่ออกรายงาน 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		บริเวณ	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางแจ้ง			
แผนผังพื้นที่ ทางเดินรับมอบใบเอกสาร Pulp M/C (หน้าห้อง Control)	P-1	607	Lux	<div><div>แสงเฉลี่ย = $\frac{10(P_1+P_2+P_3+P_4+P_5+P_6+P_7)}{8}$</div><div>P = ค่าเฉลี่ยแสงสว่างจุด 2x2 ตารางเมตร</div><div>N = จำนวนหลอดไฟแนวนอน</div></div>
	P-2	448	Lux	
	P-3	249	Lux	
	P-4	391	Lux	
	P-5	530	Lux	
	P-6	652	Lux	
	P-7	512	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง		484	Lux	ประเภทอาคาร/พื้นที่
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง		$\geq 100^1$	Lux	บริเวณพื้นที่ที่ไม่ใช่บริเวณของอาคารและ/หรืองานภายในอาคารปกติ (ภายในอาคาร)
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด		$\geq 50^1$	Lux	

หมายเหตุ :
I. ค่ามาตรฐานที่ใช้จากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561
II. วิเคราะห์ภาคสนาม
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

บันทึกคำขานงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับรอง
Page 27 of 39



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บบ้านโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงสุโขทัย อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน			
แบบทดสอบ ทางเดินขึ้นบันไดในอาคาร Pulo M/C (ใช้ระบบควบคุมแสงสว่าง Control)	P-1	51	Lux	<div><div>P-1 P-2 P-3 P-4 P-5 P-6 P-7 P-8 P-9 P-10</div><div>● ● ● ● ● ● ● ● ● ●</div><div>เครื่องจักร</div></div> <div>แสงเฉลี่ย = $\frac{(P1+P2+P3+...+Pn)}{n}$</div> <div>P = ค่าตรวจวัดแสงสว่างต่อ 2x2 ตารางเมตร</div> <div>n = จำนวนช่องแสงสว่าง</div>
	P-2	59	Lux	
	P-3	45	Lux	
	P-4	50	Lux	
	P-5	65	Lux	
	P-6	71	Lux	
	P-7	88	Lux	
	P-8	59	Lux	
	P-9	50	Lux	
	P-10	44	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง	58		Lux	บริเวณพื้นที่ที่ไม่มีมีการจัดระบบจุดแสงและ/หรืออาภาทานะในอาคารปกติ (ภายในอาคาร)
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	$\geq 100^1$		Lux	
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด	$\geq 50^1$		Lux	

หมายเหตุ :

I. ค่ามาตรฐานที่ไม่ได้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561

II. วิธีการทดสอบ

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

- "แสงสว่างไม่เพียงพอ"

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการตรวจ

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจาก



Industrial Service and Lab
SCIECO Services Company Limited
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บบ้านโป่ง)
ที่อยู่ 19 หมู่ 19 ต.แสงสุโขทัย อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน			
แบบทดสอบ				
บันไดทางขึ้นห้องไฟฟ้า P/M				
P-1	114	Lux	<div>เครื่องจักร</div> <div>แสงเฉลี่ย = $\frac{P1+P2+P3+...+Pn}{n}$ P = ค่าตรวจวัดแสงสว่างต่อ 2x2 ตารางเมตร n = จำนวนช่องแสงสว่าง</div>	
P-2	119	Lux		
P-3	110	Lux		
P-4	182	Lux		
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง	131	Lux		ประเภทอาคารพื้นที่
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	$\geq 100^1$	Lux		บริเวณพื้นที่ทั่วไปที่ใช้การสัญจรของรถและ/หรือยานพาหนะในการไป/กลับ (ภายในอาคาร)
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด	$\geq 50^1$	Lux		

หมายเหตุ :

I. ค่ามาตรฐานที่ไม่ได้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561

II. วิธีการทดสอบ

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการตรวจ

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจาก

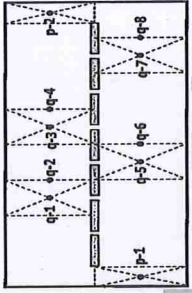


Industrial Service and Lab
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโนนัง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด	หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน		
แบบผลิตภัณฑ์ ภายในห้องพื้นที่ 2			
P-1	841	Lux	
P-2	887	Lux	
Q-1	502	Lux	
Q-2	640	Lux	
Q-3	874	Lux	
Q-4	978	Lux	
Q-5	922	Lux	
Q-6	800	Lux	
Q-7	813	Lux	$N = \frac{Q}{P} = \frac{813}{978} = 0.831$
Q-8	726	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง			Q = ค่าเฉลี่ยของ Q ทั้ง 8 จุด (ค่าเฉลี่ย ส่วนรวม)
คำนวณค่าเฉลี่ยแสงสว่าง			P = ค่าเฉลี่ยของ P ทั้ง 2 จุด (จำนวน)
คำนวณค่าเฉลี่ยแสงสว่าง			N = จำนวนหลอดไฟ
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง			ผลการตรวจวัดพื้นที่
คำนวณค่าเฉลี่ยแสงสว่าง			บริเวณพื้นที่ที่ใช้ประโยชน์ในการรวมการผลัด
คำนวณค่าเฉลี่ยแสงสว่าง			หรือการปฏิบัติงาน (ห้องควบคุม)

หมายเหตุ : I. ค่ามาตรฐานที่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความปลอดภัยแสงสว่าง พ.ศ. 2561

II. วิเคราะห์ภาคสนาม

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- เวลาทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการปฏิบัติงาน

หน้าตัดค่ารายงานผลการวิเคราะห์/ทดสอบนี้ไม่ได้เป็นบางส่วน โดยไม่ได้ยินยอมจาก

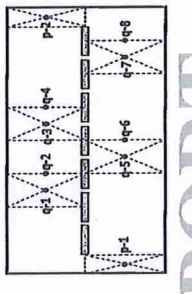


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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโนนัง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด	หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน		
แบบผลิตภัณฑ์ ภายในห้องพื้นที่			
P-1	359	Lux	
P-2	452	Lux	
Q-1	397	Lux	
Q-2	382	Lux	
Q-3	425	Lux	
Q-4	444	Lux	
Q-5	430	Lux	
Q-6	393	Lux	
Q-7	401	Lux	$N = \frac{Q}{P} = \frac{401}{452} = 0.889$
Q-8	388	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง			Q = ค่าเฉลี่ยของ Q ทั้ง 8 จุด (ค่าเฉลี่ย ส่วนรวม)
คำนวณค่าเฉลี่ยแสงสว่าง			P = ค่าเฉลี่ยของ P ทั้ง 2 จุด (จำนวน)
คำนวณค่าเฉลี่ยแสงสว่าง			N = จำนวนหลอดไฟ
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง			ผลการตรวจวัดพื้นที่
คำนวณค่าเฉลี่ยแสงสว่าง			บริเวณพื้นที่ที่ใช้ประโยชน์ในการรวมการผลัด
คำนวณค่าเฉลี่ยแสงสว่าง			หรือการปฏิบัติงาน (ห้องควบคุม)

หมายเหตุ : I. ค่ามาตรฐานที่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความปลอดภัยแสงสว่าง พ.ศ. 2561

II. วิเคราะห์ภาคสนาม

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- เวลาทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการปฏิบัติงาน

หน้าตัดค่ารายงานผลการวิเคราะห์/ทดสอบนี้ไม่ได้เป็นบางส่วน โดยไม่ได้ยินยอมจาก

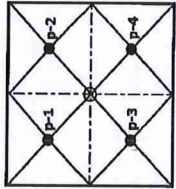


Industrial Service and Lab
SCIECO Services Company Limited
332 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.scieco.co.th E-Mail: environmentalmk@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ถนนสุขุมวิท ต.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน	หน่วย	
แผนภูมิผลิตภัณฑ์ (SCP) โดยวิธีมุม			
P-1	473	Lux	
P-2	430	Lux	
P-3	416	Lux	
P-4	449	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง	442	Lux	บริเวณพื้นที่ใช้ประโยชน์ภายในสำนักงาน (ห้องประชุม)
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	$\geq 300^1$	Lux	
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด	$\geq 150^1$	Lux	

หมายเหตุ :

I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561

II. วิเคราะห์ที่ภาคสนาม

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจากหน่วยงาน

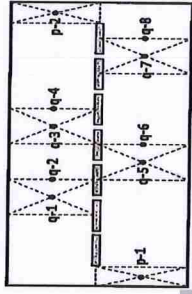


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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโป่ง)
ที่อยู่ 19 หมู่ 19 ถนนสุขุมวิท ต.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน	หน่วย	
แผนภูมิผลิตภัณฑ์ (SCP)			
พื้นที่ทดสอบกลาง (Lab)			
P-1	458	Lux	
P-2	471	Lux	
P-3	680	Lux	
P-4	642	Lux	
P-5	616	Lux	
P-6	539	Lux	
P-7	515	Lux	
P-8	498	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง	517	Lux	บริเวณพื้นที่ใช้ประโยชน์ในกระบวนการผลิต หรือการปฏิบัติงาน
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	$\geq 300^1$	Lux	
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด	$\geq 150^1$	Lux	

หมายเหตุ :

I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561

II. วิเคราะห์ที่ภาคสนาม

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจากหน่วยงาน



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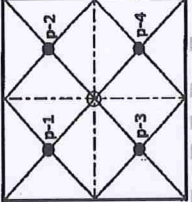


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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลัดกันสหการช่างไทย จำกัด (โรงเย็บผ้าโป่ง)
ที่อยู่ 19 หมู่ 19 อ.แสงสุโขทัย จ.พิจิตร อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน	
	ค่าจริง				
แผนผังวัดตำแหน่งและจุดสังเกต					
รูปถ่ายของพื้นที่					
P-1	355		Lux		
P-2	319		Lux		
P-3	310		Lux		
P-4	243		Lux		
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง					
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง			307	Lux	ประเภทอาคาร/พื้นที่
ค่ามาตรฐานค่าต่ำสุดแสงสว่าง			$\geq 100^1$	Lux	บริเวณพื้นที่ใช้ประโยชน์ทั่วไป
ค่ามาตรฐานค่าต่ำสุดแสงสว่าง			$\geq 50^1$	Lux	

หมายเหตุ :
I. ค่ามาตรฐานที่ใช้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561
II. สูตรที่ใช้ทดสอบ
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบ)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

หน้าตัดท้ายรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้ยินยอม
Page 34 of 39

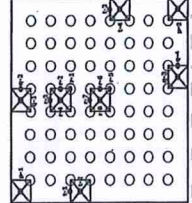


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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลัดกันสหการช่างไทย จำกัด (โรงเย็บผ้าโป่ง)
ที่อยู่ 19 หมู่ 19 อ.แสงสุโขทัย จ.พิจิตร อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด	หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน	
	ค่าจริง			
แผนผังวัดและจุดสังเกต				
รูปถ่ายของพื้นที่				
P-1	396	Lux		
P-2	367	Lux		
P-3	382	Lux		
P-4	277	Lux		
P-5	154	Lux		
P-6	185	Lux		
P-7	344	Lux		
P-8	308	Lux		
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง				
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง	251	Lux	ประเภทอาคาร/พื้นที่	
ค่ามาตรฐานจุดต่ำสุดแสงสว่าง	276	Lux	บริเวณพื้นที่ใช้ประโยชน์โดยรวมการเคลื่อนที่หรือการปฏิบัติงาน (คลังสินค้า)	
ค่ามาตรฐานจุดต่ำสุดแสงสว่าง	≥ 200 ¹	Lux		
ค่ามาตรฐานจุดต่ำสุดแสงสว่าง	≥ 100 ¹	Lux		

หมายเหตุ :
I. ค่ามาตรฐานที่ใช้มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. 2561
II. สูตรที่ใช้ทดสอบ
- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830
- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบ)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

หน้าตัดท้ายรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้ยินยอม
Page 35 of 39



Industrial Service and Lab
SCIECO Services Company Limited
332 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโนนัง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน			
แผนครัวตอกลึงและตอกลึงชัก Chipping Plant ห้องไฟฟ้าชั้นบน	P-1	510	Lux	
	P-2	436	Lux	
	Q-1	659	Lux	
	Q-2	559	Lux	
	Q-3	542	Lux	
	Q-4	624	Lux	
	Q-5	536	Lux	
	Q-6	616	Lux	
	Q-7	544	Lux	
	Q-8	425	Lux	
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง				
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง			552	Lux
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง			$\geq 200^1$	Lux
ค่ามาตรฐานค่าเฉลี่ยแสงสว่างต่ำสุด			$\geq 100^1$	Lux

หมายเหตุ :

I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561

II. วัดค่าที่ภาคสนาม

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต



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รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

โรงงาน/บริษัท บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงงานโนนัง)
ที่อยู่ 19 หมู่ 19 ต.แสงโชติ อ.ท่าเสา อ.บ้านโป่ง จ.ราชบุรี 70110
วันที่ตรวจวัด 27/08/65
เลขที่ตัวอย่าง AR22/21933
ผลการวิเคราะห์/ทดสอบ

สถานที่ตรวจวัด	ผลการตรวจวัด		หน่วย	บริเวณพื้นที่และ/หรือลักษณะงาน
	กลางวัน			
แผนกวัดกิลและอะลิสันส์ Chipping Plant ห้องเครื่องรับใบไม้ (ชั้นล่าง)	P-1	377	Lux	
	P-2	423	Lux	
	Q-1	436	Lux	
	Q-2	431	Lux	
	Q-3	480	Lux	
	Q-4	411	Lux	
	Q-5	465	Lux	
	Q-6	400	Lux	
Q-7	357	Lux	บริเวณพื้นที่และ/หรือลักษณะงาน	
Q-8	401	Lux		
ผลการตรวจวัดค่าเฉลี่ยแสงสว่าง				บริเวณพื้นที่และ/หรือลักษณะงาน
ค่ามาตรฐานค่าเฉลี่ยแสงสว่าง			หรือการปฏิบัติงาน	
ค่ามาตรฐานจุดที่แสงสว่างต่ำสุด				

หมายเหตุ :

I. ค่ามาตรฐานที่ไม่มาจากประกาศกรมสวัสดิการและคุ้มครองแรงงาน เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ.2561

II. วัดค่าที่ภาคสนาม

- ตรวจวัดโดย Lux Meter ยี่ห้อ : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- กลางวันทำการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์ผลการดำเนินงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาต



Industrial Service and Lab

SCIECO Services Company Limited

352 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone : +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.sciteco.th E-Mail: environmentalmk1@scg.com, calibrate@scg.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเย็บบ้านโป่ง)

19 หมู่ 19 อ.แสงวัฒนา ต.ท่าผา อ.บ้านโป่ง จ.ราชบุรี 70110

วันที่

เลขที่ตัวอย่าง
AR27/21933
27/06/05

นิพนธ์ นาคะ ANKZ

ผอ.กรร.เอราวัณ/ทอสอบ

[illegible]

หมายเหตุ :

๒๕๖๑ : เรื่องมาตรฐานความเข้มของแสงสว่าง พ.ศ. ๒๕๖๑

II. วิเคราะห์ที่ภาคสนาม

- ตรวจวัดด้วย Lux Meter รุ่น : 407026 หมายเลขเครื่อง : Q653830

- ตั๋วรถไฟใต้ดิน LUX Metro บัตร : LUX Card และบัตรอื่นๆ
- คลองรับทำการตรวจวัดระหว่างเวลา 10:00 น. – 16:30 น.

(รับรองผลเฉพาะตัวอย่างที่ได้วิเคราะห์/ทดสอบเท่านั้น)

บุคคลหรือนิติบุคคลผู้ดำเนินการตรวจวัดและวิเคราะห์สภาพการทำงาน

ห้ามคัดถ่ายรายงานผลการวิเคราะห์/ทดสอบนี้แต่เพียงบางส่วน โดยไม่ได้รับอนุญาตจ

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Industrial Service and Lab

SCIECO Services Company Limited

SCS ECO SERVICES COMPANY LIMITED
33/2 Moo 3, Banpa, Kaeng Khoi, Saraburi 18110, Thailand
Environment Telephone: +66 (0) 3627 3099 Fax : +66 (0) 3627 3100
Calibration Telephone : +66 (0) 3627 3096 Fax : +66 (0) 3627 3100
www.scs-eco.co.th E-Mail: environmental@skt@scs.com, calibrate@scs.com

รายงานผลการตรวจวัดความเข้มของแสงสว่างในสถานที่ทำงาน

Report No. AA 22/0498

บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด (โรงเรียนโปง)

19 พ.ค. 19 อ.แสงทวี ด.ท่าผา อ.บ้านโป่ง จ.ราชบุรี 70110

[illegible]

အမည် ဦးအောင်
 အမှတ် ၁၃၃၇၁၉၃၃
 ၁၉၆၆/၇/၁၇

เลขที่ตรวจใบ เอกสาร/พดสอ ARZ

ผลการตรวจวัด	หน่วย	
	กลางวัน	
<p>ข้อมูลของสถานที่</p> <p>ประเภทของอาคาร</p>		
p-1	758	Lux
p-2	846	Lux
	971	Lux
q-1	747	Lux
q-2	730	Lux
q-3	821	Lux
q-4	888	Lux
q-5	894	Lux
q-6	712	Lux
q-7	845	Lux
q-8		
ผลการตรวจวัดค่าแสงสว่าง	823	Lux
ค่ามาตรฐานค่าแสงสว่าง	≥ 300	Lux
ค่าตรวจวัดค่าแสงสว่าง	≥ 150	Lux

หมายเหตุ :

ยเหตุ :
I. คำมาตรฐานที่นำมาจากระกาศกรณสวัสดิการและคัมครองแสงสว่าง พ.ศ.2561

II. วิเคราะห์ที่ภาคสนาม

ค่าวัดโดย Flux Meter รุ่น : EXTECH Instrument รุ่น : 407026 หมายเลขเครื่อง : Q653830

- ตารางวัดแบบ EMX Model ย่อ : EX Model
- คลังงานเพื่อการตรวจวัดระหว่างเวลา 10:00 น. - 16:30 น.

(ผู้ทรงคุณวุฒิเฉพาะด้านที่ปรึกษา/ทดสอบแข่งขัน)

บอดลิ่งหรือบัณฑิตผู้ดำเนินการตรวจวัดและวิเคราะห์การทำงาน

ห้ามคัดค้านรายงานผลการวิเคราะห์/ทดสอบตั้งแต่เพียงบางส่วน โดยไม่ได้รับอนุญาต

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เอกสารแนบที่ 2.29

การเตรียมแผนการหรือมาตรการป้องกันอุบัติภัย

เอกสารแนบที่ 2.30

การทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

JOCKEY PUMP

CONTROLLER TEST			
C O N T R O L L E R	1. Manual Start - Stop	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	2. Automatic Start - Stop	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input checked="" type="checkbox"/> N/A
	3. Power Supply Condition <u>380</u> V.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	4. Magnetic Contactor Start <input checked="" type="checkbox"/> D.O.L. <input type="checkbox"/> Star-Delta	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	5. Overload Relay <u>11</u> A. Set at <u>7.0</u> A	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	6. Time Off Relay (Set <u>10</u> Seconds)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	7. Pressure Switch Test (Start Set <u>-</u> psi.) (Stop Set <u>-</u> psi.)	<input type="checkbox"/> Passed <input type="checkbox"/> Not Passed <input checked="" type="checkbox"/> N/A	
TEST DATA			
1. Discharge Pressure <u>-</u> psi.			
2. Suction Pressure <u>-</u> psi.			
3. Water Flow Rate <u>-</u> gpm.			
4. Relief Valve Setting <u>-</u> psi., Pump Speed <u>-</u> rpm.			
5. Voltage (R-S, S-T, T-R) <u>396</u> , <u>397</u> , <u>397</u> Volts			
6. Running Amperage (R, S, T) <u>3.2</u> , <u>3.1</u> , <u>3.1</u> A.			
7. Pressure cut-in <u>-</u> psi.			
8. Pressure cut-off <u>-</u> psi.			
9. Working Pressure <u>-</u> psi.			

Remark :

1. เช็ทของหัวปั๊ม (Mechanical seal) การเปลี่ยนใหม่
2. บารอมิเตอร์ (Pressure gauge) พบว่าค่าบารอมิเตอร์เกิน

ANNUAL FLOW TEST REPORT (2022)

FOR THE MONTH OF MAY 2022

DIESEL ENGINE FIRE PUMP No.1 (Clear Well #1)

Project Name : บริษัท ตามมาทรีฟลูอิดไฮดรอลิค จำกัด (มหาชน)		Service Date : 17/05/2022	Time : 9:30 U.
Job no. : 5000027893		Contract no.	Technician : นายสุชาติ เจริญทดาก
Customer Name : บริษัท ตามมาทรีฟลูอิดไฮดรอลิค จำกัด (มหาชน)		Engineer : นายพณณ ทอดศิริกุล	
Address : 19 หมู่ที่ 19 อ. บางคูเวต จ.นนทบุรี 70110		Remarks :	
Tel : (093) 197-3311		Fax :	
Attention : คุณสมศักดิ์		Date : 17/05/2022	
UNIT DATA			
PUMP	ENGINE	CONTROLLER	
Pump Brand : PEERLESS	Engine Brand : CLARKE	Control Brand : FIRETROL	
Model : 6AEF12	Model : TK6HUF80	Model : FTA 1100-JL12N	
S/N : 628322	S/N : 935883	S/N : 246352-07RE	
<input checked="" type="checkbox"/> UL LISTED <input checked="" type="checkbox"/> FM APPROVED	<input checked="" type="checkbox"/> UL LISTED <input checked="" type="checkbox"/> FM APPROVED	<input checked="" type="checkbox"/> UL LISTED <input checked="" type="checkbox"/> FM APPROVED	
Pump speed : 2,800 rpm	Horse Power : 273 Hp	Power supply 220 V, 1 PH, 50 HZ	
Flow Rate : 1,500 gpm.	Engine Speed : 2,800 rpm.		
TDH : 160 psi.	Power supply : 12 VDC.		
Max. working Pressure : - psi.			
PRE - START UP DATA			
P	1. Suction Gate Valve	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
U	2. Discharge Gate Valve	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
M	3. Inboard ball bearing	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
P	4. Outboard ball bearing	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	5. Packing Seal (front & back)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	6. Suction pressure <u>4.4</u> psi, Discharge pressure <u>153</u> psi.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
ENGINE TEST			
E	1. Manual Crank on Battery # 1	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
N	2. Manual Crank on Battery # 2	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
G	3. Low Oil Pressure <u>65</u> psi.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
I	4. Fuel Pressure <u>-</u> psi.	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input checked="" type="checkbox"/> N/A
N	5. Water Temperature <u>71</u> °C	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
E	6. Service Hour Meter <u>278.1 / 278.7</u> hr.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	7. Tachometer <u>2,800</u> rpm.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A

DIESEL ENGINE FIRE PUMP

CONTROLLER TEST			
C O N T R O L L E R	1. Checking Starting Battery # 1	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	2. Checking Starting Battery # 2	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	3. Automatic Start by Draining Water System	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	4. Manual Stop by Engine Shut Down	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	5. Battery Charger # 1 (12.84 Volts)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	6. Battery Charger # 2 (12.98 Volts)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	7. Test Charger Malfunction <u>-</u> VDC	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	8. Automatic Weekly Starting Test	<input type="checkbox"/> Passed <input type="checkbox"/> Not Passed <input checked="" type="checkbox"/> N/A	
	Start Day <u>-</u> Time <u>-</u> Stop Day <u>-</u> Time <u>-</u>		
	9. Water Temperature <u>71</u> °C	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	10. Low Oil Pressure <u>65</u> psi.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	11. Engine Over Speed	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	12. Failed to Start	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
	13. Timer Off Relay (Set <u>-</u> min)	<input type="checkbox"/> Passed <input type="checkbox"/> Not Passed <input checked="" type="checkbox"/> N/A	
14. Pressure Switch Test (Start Set <u>65</u> psi.) (Stop Set <u>70</u> psi.) Manual Stop	<input type="checkbox"/> Passed <input type="checkbox"/> Not Passed <input checked="" type="checkbox"/> N/A		
TEST DATA			
1. Discharge Pressure <u>153</u> psi.			
2. Suction Pressure <u>4.4</u> psi.			
3. Water Flow Rate <u>1,501.22</u> gpm.			
4. Pump Speed <u>2,866.2</u> rpm. Relief Valve Setting <u>155</u> psi.			
5. Pressure cut-in <u>65</u> psi.			
6. Working Pressure <u>153</u> psi.			

Remark :

1. บารอมิเตอร์วัดรอบเครื่องเกินค่าที่กำหนด
2. มีน้ำมันรั่วซึมจาก Oil Pressure Switch

FIRE PUMP PERFORMANCE TESTS (Annual Test, Year 2022)

Test Date : May 17, 2022

Pump Number : No.1 (Clear Well #1)

Location : Pump Room

Test Number (at Point)	1	2	3	4	5	6	7
Percent of rated pump discharge test	0%	25%	50%	75%	100%	125%	150%
Flow Rate (gpm) , Actual Test	0	376.222	750.778	1,126.05	1,501.22	1,876.05	2,250.85
Suction Pressure (psi) , Actual Test	6	6	5.8	5.2	4.4	3	1
Discharge Pressure (psi) , Actual Test	200	190	183	170	153	130	100
Net Pressure (psi) (Discharge Pressure Minus Suction Pressure)	194	184	177.2	164.8	148.6	127	99
Pump Speed (rpm) , Actual Test	2,943.0	2,939.5	2,904.4	2,884.8	2,866.2	2,852.8	2,842.8

FIRE PUMP PERFORMANCE TESTS (Annual Test, Year 2021)

Test Date : September 4, 2021

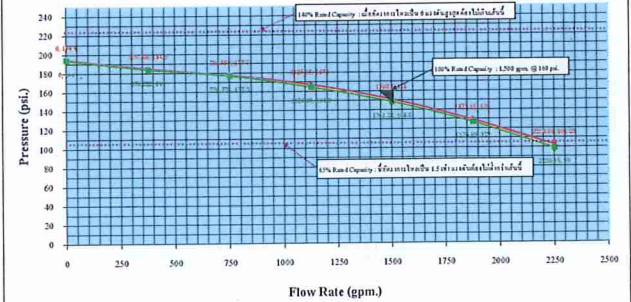
Pump Number : No.1 (Clear Well #1)

Location : Pump Room

Test Number (at Point)	1	2	3	4	5	6	7
Percent of rated pump discharge test	0%	25%	50%	75%	100%	125%	150%
Flow Rate (gpm), Actual Test	0	375.766	750.539	1,125.15	1,500.40	1,875.16	2,250.16
Suction Pressure (psi), Actual Test	3.6	3.5	3.3	2.9	2	1	-0.25
Discharge Pressure (psi), Actual Test	198	188	181	170	153	130	102
Net Pressure (psi) (Discharge Pressure Minus Suction Pressure)	194.4	184.5	177.7	167.1	151	129	102.25
Pump Speed (rpm), Actual Test	2,919.2	2,909.0	2,899.5	2,866.5	2,848.6	2,835.8	2,824.2

Flow Rate and Pressure Record

Pump Curve (Year 2021) Pump Curve (Year 2022)
Location : Pump Room, Pump Number : Clear Well No.1



FIRE PUMP PERFORMANCE TESTS (Annual, Test Year 2022)

Test Date : May 17, 2022

Pump Number : No.1 (Clear Well #1)

Location : Pump Room

- การทดสอบการไหลของน้ำจากห้องปั๊มสูบน้ำดับเพลิง (โดยใช้อุปกรณ์วัดอัตราการไหล "ULTRA SONIC" Flow Meter) พบว่าอัตราการไหลของน้ำจากห้องปั๊มสูบน้ำดับเพลิง (โดยใช้อุปกรณ์วัดอัตราการไหล "ULTRA SONIC" Flow Meter) มีค่าเท่ากับ 1,125.15 gpm (100% Rated) ซึ่งสูงกว่าค่าที่ระบุไว้ในใบข้อมูล Nameplate ที่ค่าอัตราการไหลของน้ำดับเพลิงประมาณ 7% และเมื่อเปรียบเทียบกับผลการทดสอบประจำปี 2021 พบว่าค่าอัตราการไหลของน้ำดับเพลิงเพิ่มขึ้น
- จากการทดสอบการไหลของน้ำจากห้องปั๊มสูบน้ำดับเพลิง (Flow Rate) กับแรงดันของน้ำที่ส่งออกไปยังหัวฉีด (Net Pressure) พบว่า ไม่สามารถทำการวัดแรงดันของน้ำที่ส่งออกไปยังหัวฉีดได้ เนื่องจากไม่มีหัวฉีดที่ใช้งานได้ (Original Pump Curve) ของห้องปั๊มสูบน้ำดับเพลิง

ANNUAL FLOW TEST REPORT (2022)

FOR THE MONTH OF MAY 2022

JOCKEY PUMP No.2 (Clear Well #2, PM.#16)

Project Name : บริษัท สยามทราฟฟิคส์ จำกัด (มหาชน) (Siam Traffic Co., Ltd.)		Service Date : 17/05/2022 Time : 11:00 H.	
Job no. : 5000027895		Contract no. :	
Customer Name : บริษัท สยามทราฟฟิคส์ จำกัด (มหาชน) (Siam Traffic Co., Ltd.)		Technician : นายสุวิทย์ เจริญกลาง	
Address : 19 หมู่ที่ 19 อ. แสงสุโขทัย จ. อุตรดิตถ์ 67110		Engineer : นายพชรพล พลอติสุข	
Tel : (093) 197-3311		Remarks :	
Fax : :			
Attention : คุณธนพัฒน์		Date : 17/05/2022	
UNIT DATA			
PUMP		MOTOR	
Pump Brand : GRUNDFOS		Brand : Bulk-in	
Model : CR5-24		Model : -	
S/N : A96513390P11414		S/N : -	
Pump speed : 2,917 rpm.		Speed : 2,920 rpm.	
Flow Rate : 25 U.S.GPM.		Type : 4.0 kW.	
TDHL : 180 psi (12.5 m.)		Power supply : 380 V., 3 Ph., 50 Hz.	
Max. working Pressure : - psi.		Full Load : 8.7 A.	
Control Brand : FIRETROL		Model : FTA 550F-AG003F	
S/N : 934511-02		S/N : 934511-02	
UL LISTED		FM APPROVED	
Type start		D.O.L.	
Star-Delta			
PRE-START UP DATA			
P	1. Suction Gate Valve	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
U	2. Discharge Gate Valve	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
M	3. Mechanical seals (front)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
P	4. Vibration	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
MOTOR TEST			
-	1. Inboard ball bearing	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A
-	2. Outboard ball bearing	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed <input type="checkbox"/> N/A

CONTROLLER TEST

CONTROLLER TEST				
C	1. Manual Start - Stop	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
O	2. Automatic Start - Stop	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A
N	3. Power Supply Condition <u>380</u> V.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
T	4. Magnetic Contactor Start <input checked="" type="checkbox"/> D.O.L. <input type="checkbox"/> Star-Delta	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
R	5. Overload Relay <u>10</u> A, Set at <u>8.5</u> A	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
O	6. Time Off Relay (Set <u>10</u> Seconds)	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A
L	7. Pressure Switch Test (Start Set <u>72</u> psi.)	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A
L	(Stop Set <u>87</u> psi.)	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A
E				
R				
TEST DATA				
1.	Discharge Pressure <u> </u> psi.			
2.	Suction Pressure <u> n/a </u> in.Hg.			
3.	Water Flow Rate <u> - </u> gpm.			
4.	Relief Valve Setting <u> </u> psi., Pump Speed <u> </u> rpm.			
5.	Voltage (R-S, S-T, T-R) <u>386</u> , <u>384</u> , <u>393</u> Volt			
6.	Running Amperage (R, S, T) <u>6.5</u> , <u>6.5</u> , <u>6.5</u> A.			
7.	Pressure cut-in <u> 72 </u> psi.			
8.	Pressure cut-off <u> 87 </u> psi.			
9.	Working Pressure <u> </u> psi.			

Remark :

1. ไม่นับควรวัดแรงดันในเส้นท่อด้านจ่าย (Pressure Gauge)

FOR THE MONTH OF MAY 2022

DIESEL ENGINE FIRE PUMP No.2 (Clear Well #2, PM.#16)

Project Name : มินิหมั ตยตามหลักวิศวกรรม ฉบับ (โรงงานปั่นไอล)		Service Date : 17/05/2022		Time : 11:00 A.M	
Job no. : 5000027895		Contract no.		Technician : นายสุชาติ เต็มหน้าดาว	
Customer Name : มินิหมั ตยตามหลักวิศวกรรม ฉบับ (โรงงานปั่นไอล)		Engineer : มหัทธมน หนองศรีสุข		Remarks :	
Address : 19 หมู่ที่ 19 อ.บึงสามพัน จ.ราชบุรี 70110					
Tel : (093) 197-3311		Fax :			
Attention : ภูมรินทร์		Date : 17/05/2022			
UNIT DATA					
PUMP		ENGINE		CONTROLLER	
Pump Brand : PEERLESS		Engine Brand : CLARKE		Control Brand : FIRETROL	
Model : RAEF20G		Model : DQ6H-4U/AA88		Model : FTA109-JL4H	
S/N : 992704773-10-A		S/N : DLH60Q600430621		S/N : 1045472-01RE	
<input checked="" type="checkbox"/> UL LISTED <input checked="" type="checkbox"/> FM APPROVED		<input checked="" type="checkbox"/> UL LISTED <input checked="" type="checkbox"/> FM APPROVED		<input checked="" type="checkbox"/> UL LISTED <input checked="" type="checkbox"/> FM APPROVED	
Pump speed : 1,760 rpm.		Horse Power : 375 Hp.		Power supply 220 V, 1 PH, 50 HZ	
Flow Rate : 2,500 gpm.		Engine Speed : 1,760 rpm.			
FDH. : 164 psi.		Power supply : 24 VDC.			
Max. working Pressure : 182 psi.					
PRE - START UP DATA					
P U M P	1. Section Gate Valve	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
	2. Discharge Gate Valve	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
	3. Inboard ball bearing	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
	4. Outboard ball bearing	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
	5. Packing Seal (front & back)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
	6. Suction pressure <u>4.4</u> psi. Discharge pressure <u>123</u> psi.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
ENGINE TEST					
E	1. Manual Crank on Battery # 1	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
N	2. Manual Crank on Battery # 2	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
G	3. Low oil Pressure <u>53</u> psi.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
I	4. Fuel Pressure <u>-</u> psi.	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A	
N	5. Water Temperature <u>70</u> °C	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
E	6. Service Hour Meter <u>161.4 / 161.9</u> hr.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	
	7. Tachometer <u>1,800</u> rpm.	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A	

CONTROLLER TEST

CONTROLLER TEST				
	1. Checking Starting Battery # 1	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
	2. Checking Starting Battery # 2	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
C	3. Automatic Start by Draining Water System	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
O	4. Manual Stop by Engine Shut Down	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
N	5. Battery Charger # 1 (<u>26.07</u> Volts)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
T	6. Battery Charger # 2 (<u>25.46</u> Volts)	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
R	7. Test Charger Malfunction - <u> </u> VDC	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
	8. Automatic Weekly Starting Test	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A
O	Start Day - <u> </u> Time - <u> </u> Stop Day - <u> </u> Time - <u> </u>			
L	9. Water Temperature <u>20</u> °C	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
L	10. Low Oil Pressure <u>55</u> psi.	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
E	11. Engine Over Speed	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
	12. Failed to Start	<input checked="" type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input type="checkbox"/> N/A
R	13. Timer Off Relay (Set - <u> </u> min)	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A
	14. Pressure Switch Test (Start Set <u>63</u> psi.)	<input type="checkbox"/> Passed	<input type="checkbox"/> Not Passed	<input checked="" type="checkbox"/> N/A
	(Stop Set <u> </u> psi.) Manual Stop			
TEST DATA				
1. Discharge Pressure <u>175</u> psi.				
2. Suction Pressure <u>6.4</u> psi.				
3. Water Flow Rate <u>2.501.46</u> gpm.				
4. Pump Speed <u>1,785.4</u> rpm. Relief Valve Setting <u>175</u> psi.				
5. Pressure cut-in <u>65</u> psi.				
6. Working Pressure <u>175</u> psi.				

Remark :

1. มาตราวัดแรงดัน (Compound gauge) ของท่อด้านหลุมชำรุด

2. ไอเสียของเครื่องยนต์ รั่วออกบริเวณหน้าแปลนท่อร่วมไอเสีย

3. ไม่มีชุดผ้าพร้อมฉนวนทนความร้อนกันชุดท่อร่วมไอเสีย ของเครื่องยนต์

FIRE PUMP PERFORMANCE TESTS (Annual ,Test Year 2022)

Test Date : May 12, 2022

Pump Number : No.2 (Clear Well #2, FM#16)

Location : ~~Paint Room~~ (PM#16)

Test Number (at Point)	1	2	3	4	5	6	7
Percent of rated pump discharge rate	0%	25%	50%	75%	100%	125%	150%
<i>Pipe Rate (gpm), Actual Test</i>	0	625.621	1,251.46	1,875.84	2,501.46	3,125.21	3,750.10
Actual Pressure (psi), Actual Test	6.5	6.5	6.5	6.5	6.4	6.2	5.8
Discharge Pressure (psi), Actual Test	196	195	192	185	175	160	140
Sat Pressure (psi) (Discharge Pressure Minus Static Pressure)	189.5	188.5	185.5	178.5	168.6	153.8	134.2
Pump Speed (rpm), Actual Test	1,813.9	1,809.0	1,801.5	1,792.0	1,785.4	1,777.7	1,769.7

Original Pump Curve Data (PEERLESS, model: 8AET20G)

Flow Rate (gpm), Original Pump Curve	0	625	1,250	1,875	2,500	3,125	3,750
Discharge Pressure (psi), Original Pump Curve	181	169	179	174	164	152	135



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ก่อนทำการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง



รูปที่ ๑ การติดตั้งเซ็นเซอร์ (Sensor) ขงเครื่องมือวัดอัตราการไหลของน้ำ (Flow Rate) ภายในเส้นท่อน้ำดับเพลิง



รูปที่ 2 คุณภาพนิเทศน์คดีหมายเลข 87.2 อสมทเขตจันทบุรี

ขณะทำการทดสอบคว่ำงูขึ้นน้ำด้วยหลักนี้บันทึกผล ค่าที่ 1 (เพื่อทราบการไหลของคว่ำงูขึ้นน้ำด้วยหลัก 0 %)



ข้อ 11 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 0 แกลลอนต่ออนาที (inHg.)



รูปที่ 2 ความเร็วรอบเครื่องยนต์ (Engine Speed)
ที่อ่านค่าได้ เท่ากับ **2,943.0** รอบต่อนาที (rpm.)



รูปที่ 3 Suction Pressure ที่อ่านค่าได้เท่ากับ 6 psi.



ข้อที่ 4 Discharge Pressure ที่อ่านค่าได้เท่ากับ 200 psi.

ขอแบ่งการทดสอบตัวอย่างน้ำดื่มดิบเพิ่มอีกอีก 2 (ที่ดำเนินการในหลอดน้ำดื่มดิบ 25%)



รูปที่ ๔ อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ **376.222** แกลลอนต่ออนาที (gpm.)



รูปที่ 6 ความเร็วรอบเครื่องยนต์ (Engine Speed)
ที่อ่านค่าได้เท่ากับ 2,930.5 รอบต่อนาที (rpm.)



รูปที่ 7 Suction Pressure ที่อ่านค่าได้เท่ากับ 6 psi.



รูปที่ 8 Discharge Pressure ที่อ่านค่าได้เท่ากับ 190 psi.

จะทำการทดสอบเครื่องสูบน้ำด้วยวิธีดังนี้คือ ทดสอบที่ 3 (ที่อัตราการไหลของเครื่องสูบน้ำด้วยพลัง 50 %)



สรุปที่ 9 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ **750.778** แกลลอนต่อนาที (gpm.)



รูปที่ 10 ความเร็วรอบเครื่องยนต์ (Engine Speed)
ที่อ่านค่าได้เท่ากับ 2,904.4 รอบต่อนาที (rpm.)



รูปที่ 11 Suction Pressure ที่อ่านค่าได้เท่ากับ 5.8 psi.



รูปที่ 12 Discharge Pressure ที่อ่านค่าได้เท่ากับ **183** psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 1 (Fire Pump No.1)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผลค่าที่ 4 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 75 %)



รูปที่ 13 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 1,126.05 แกลลอนต่อนาที (gpm.)



รูปที่ 14 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 2,884.8 รอบต่อนาที (rpm.)



รูปที่ 15 Suction Pressure ที่อ่านค่าได้เท่ากับ 5.2 psi.



รูปที่ 16 Discharge Pressure ที่อ่านค่าได้เท่ากับ 170 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 1 (Fire Pump No.1)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผลค่าที่ 5 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 100%)



รูปที่ 17 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 1,501.22 แกลลอนต่อนาที (gpm.)



รูปที่ 18 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 2,866.2 รอบต่อนาที (rpm.)



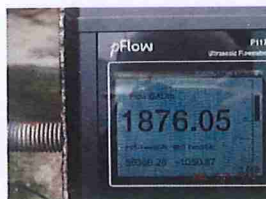
รูปที่ 19 Suction Pressure ที่อ่านค่าได้เท่ากับ 4.4 psi.



รูปที่ 20 Discharge Pressure ที่อ่านค่าได้เท่ากับ 153 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 1 (Fire Pump No.1)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผลค่าที่ 6 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 125 %)



รูปที่ 21 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 1,876.05 แกลลอนต่อนาที (gpm.)



รูปที่ 22 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 2,852.8 รอบต่อนาที (rpm.)



รูปที่ 23 Suction Pressure ที่อ่านค่าได้เท่ากับ 3 psi.



รูปที่ 24 Discharge Pressure ที่อ่านค่าได้เท่ากับ 130 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 1 (Fire Pump No.1)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผลค่าที่ 7 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 150 %)



รูปที่ 25 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 2,250.05 แกลลอนต่อนาที (gpm.)



รูปที่ 26 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 2,842.8 รอบต่อนาที (rpm.)



รูปที่ 27 Suction Pressure ที่อ่านค่าได้เท่ากับ 1 psi.



รูปที่ 28 Discharge Pressure ที่อ่านค่าได้เท่ากับ 100 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

ก่อนทำการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง



รูปที่ 1 การติดตั้งเซ็นเซอร์ (Sensor) ของเครื่องวัดอัตราการไหลของน้ำ (Flow Rate) ภายในเส้นท่อน้ำดับเพลิง



รูปที่ 2 ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิง 74.2 ลิตรต่อวินาที

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงแบบติดต่อกันที่ 1 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 0.5%)



รูปที่ 3 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 0 แกลลอนต่อนาที (gpm.)



รูปที่ 4 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 1,813.9 รอบต่อนาที (rpm.)



รูปที่ 5 Suction Pressure ที่อ่านค่าได้เท่ากับ 6.5 psi.



รูปที่ 6 Discharge Pressure ที่อ่านค่าได้เท่ากับ 196 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงแบบติดต่อกันที่ 2 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 25.5%)



รูปที่ 7 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 625.621 แกลลอนต่อนาที (gpm.)



รูปที่ 8 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 1,809.0 รอบต่อนาที (rpm.)



รูปที่ 9 Suction Pressure ที่อ่านค่าได้เท่ากับ 6.5 psi.



รูปที่ 10 Discharge Pressure ที่อ่านค่าได้เท่ากับ 195 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงแบบติดต่อกันที่ 3 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 50.5%)



รูปที่ 11 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 1,251.46 แกลลอนต่อนาที (gpm.)



รูปที่ 12 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 1,801.5 รอบต่อนาที (rpm.)



รูปที่ 13 Suction Pressure ที่อ่านค่าได้เท่ากับ 6.5 psi.



รูปที่ 14 Discharge Pressure ที่อ่านค่าได้เท่ากับ 192 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงกับพื้นที่ค่าที่ 4 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 75 %)



รูปที่ 13 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 1,875.84 แกลลอนต่อนาที (gpm.)



รูปที่ 14 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 1,792.0 รอบต่อนาที (rpm.)



รูปที่ 15 Suction Pressure ที่อ่านค่าได้เท่ากับ 6.5 psi.



รูปที่ 16 Discharge Pressure ที่อ่านค่าได้เท่ากับ 185 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงกับพื้นที่ค่าที่ 5 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 100 %)



รูปที่ 17 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 2,501.46 แกลลอนต่อนาที (gpm.)



รูปที่ 18 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 1,785.4 รอบต่อนาที (rpm.)



รูปที่ 19 Suction Pressure ที่อ่านค่าได้เท่ากับ 6.4 psi.



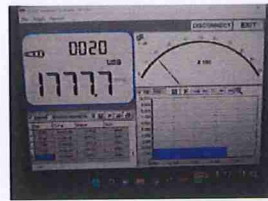
รูปที่ 20 Discharge Pressure ที่อ่านค่าได้เท่ากับ 175 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงกับพื้นที่ค่าที่ 6 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 125 %)



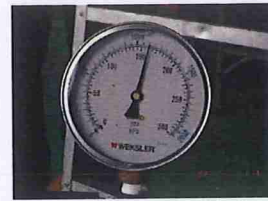
รูปที่ 21 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 3,125.21 แกลลอนต่อนาที (gpm.)



รูปที่ 22 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 1,777.7 รอบต่อนาที (rpm.)



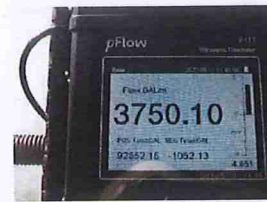
รูปที่ 23 Suction Pressure ที่อ่านค่าได้เท่ากับ 6.2 psi.



รูปที่ 24 Discharge Pressure ที่อ่านค่าได้เท่ากับ 160 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิงชุดที่ 2 (Fire Pump No.2)

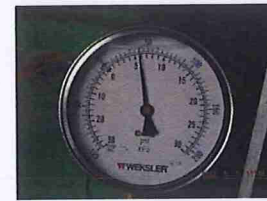
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงกับพื้นที่ค่าที่ 6 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 150 %)



รูปที่ 25 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 3,750.10 แกลลอนต่อนาที (gpm.)



รูปที่ 26 ความเร็วรอบเครื่องยนต์ (Engine Speed) ที่อ่านค่าได้เท่ากับ 1,769.7 รอบต่อนาที (rpm.)



รูปที่ 27 Suction Pressure ที่อ่านค่าได้เท่ากับ 5.8 psi.



รูปที่ 28 Discharge Pressure ที่อ่านค่าได้เท่ากับ 140 psi.

3. เอกสารของผู้ควบคุมงานการทดสอบ

D:\Program\SCS (User Control Group)\ผู้ควบคุมงานการทดสอบ & ควบคุมงานวัดค่าในถัง (KROHNE Flow Pump Annual Test)\2018\Index Report_Flow Pump Index

4. รายละเอียดของเครื่องมือวัดที่เกี่ยวข้องกับการทดสอบ

D:\Program\SCS (User Control Group)\ผู้ควบคุมงานการทดสอบ & ควบคุมงานวัดค่าในถัง (KROHNE Flow Pump Annual Test)\2018\Index Report_Flow Pump Index

Description of Test Standard
Flow tested using a six-inch electromagnetic meter Krohne model IFS-4000F, serial number C7874-03/359. This electromagnetic meter is used as a master meter and was calibrated against Krohne's master meter, which is proven regularly against a fixed-volume tank. The calibration certificate of this tank documents the traceability to national standards, which realize the physical units of measurement according to the international System of Units(SI).

Calibration Data for Unit Under Test					
AVERAGE FLOW FOR REFERENCE:(m³/hour)	FLOW STANDARD TOTALIZED FLOW (L)	UNIT UNDER TEST TOTALIZED FLOW (L)	SCALE (KI)	REPEATABILITY (%)	PASSED
304.506	5075.096	4626.037	1.097	0.13	YES
178.374	2972.898	2721.570	1.092	0.04	YES
53.093	884.878	812.667	1.089	0.13	YES

Standard Deviation: ±0.26% of Reading

Carbon Steel Pipe ,I.D.=156mm,Wall=6mm

Calibration Date: Mar. 03, 2022

NOTE: The Scale Factor has already been programmed into Menu 45 of the meter.

150
Calibration Conducted By



MIRACLE INTERNATIONAL TECHNOLOGY CO.,LTD
214 Bangwaek Rd. Bangpai Bangkok 10160
Tel: 0-2865-4647-8 Fax: 0-2865-4649 <http://www.mit.in.th>



CALIBRATION CERTIFICATE

Certificate No.: AD2108-102-0002
Date Issued: 11-Aug-21

Customer: Pyrotech Engineering Co.,Ltd.
19/29-30 M.13 Soi Navamin 50, Navamin Rd., Klongkhum,
Buengkhum, Bangkok 10240

Equipment: Pressure Gauge

Manufacturer: WEKSLER
Model: W-BY14YPJ4LWJLMTG
Serial No.: -
ID No./Tag No.: C21-496
Date Received: 10-Aug-21
Date Calibrated: 11-Aug-21

Calibrated by: Mr. Sonjet Onbua

Calibration Method or Calibration Procedure Used

In-house method: CP-07 base on DKD-R 6-1: Edition 3 2014.

This certificate is traceable to national standards, which realize the units of measurement according to the International System of Units (SI).

Result of Calibration

The reported uncertainty of measurement was based on standard uncertainty multiplied by a coverage factor $k = 2$, providing a level confidence approximately 95 percent.

This certificate may not be reproduced other than in full except with the prior written approval of the Technical Manager, Miracle International Technology Company Limited.

Approved by:

(Mr. Tassanai Suksukon)
Technical Manager



Page 1 of 2

Certificate No.: AD2108-102-0002

Environment: Ambient Temperature: $(25 \pm 2)^\circ\text{C}$
Relative Humidity: $(50 \pm 15)\%\text{RH}$

UUC Reading psi	STD Reading (psi) Before Adjusted	STD Reading (psi) After Adjusted	UUC Error psi	Uncertainty \pm psi
0	0.0	-	0.0	1.4
50	50.7	-	-0.7	1.4
100	100.8	-	-0.8	1.4
150	151.2	-	-1.2	1.4
200	201.0	-	-1.0	1.4
250	250.6	-	-0.6	1.4
300	300.1	-	-0.1	1.4

STD = Standard

UUC = Unit Under Calibration

Calibrated condition: Pressure Medium: Air: Density = 1.19 kg/m^3 @ 20°C , 1 bar
Mounting Position: Vertical
Reference Level: at center of its dial
Conversion Factor: Multiply by $6.894757 \text{ E}+03$ - Pa unit

Description of UUC: Range: 0 - 300 psi
Calibration Range: 0 - 300 psi
Scale Interval: 5 psi
Resolution: 1 psi

Measurement Standards Used & Traceability:

The International System of Units (SI) through

MIT Certificate No. AD2101-289-0001 for Pressure Calibrator 70 bar Serial No. 3544972, Due 02-Feb-22

End of Certificate

Page 2 of 2



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214 Bangwaek Rd. Bangpai Bangkok 10160
Tel: 0-2865-4647-8 Fax: 0-2865-4649 <http://www.mit.in.th>



CALIBRATION CERTIFICATE

Certificate No.: AD2108-102-0001
Date Issued: 11-Aug-21

Customer: Pyrotech Engineering Co.,Ltd.
19/29-30 M.13 Soi Navamin 50, Navamin Rd., Klongkhum,
Buengkhum, Bangkok 10240

Equipment: Pressure Gauge

Manufacturer: WEKSLER
Model: W-BY14YCB4LWJLMTG
Serial No.: -
ID No./Tag No.: C21-495
Date Received: 10-Aug-21
Date Calibrated: 11-Aug-21

Calibrated by: Mr. Sonjet Onbua

Calibration Method or Calibration Procedure Used

In-house method: CP-07 base on DKD-R 6-1: Edition 3 2014.

This certificate is traceable to national standards, which realize the units of measurement according to the International System of Units (SI).

Result of Calibration

The reported uncertainty of measurement was based on standard uncertainty multiplied by a coverage factor $k = 2$, providing a level confidence approximately 95 percent.

This certificate may not be reproduced other than in full except with the prior written approval of the Technical Manager, Miracle International Technology Company Limited.

Approved by:

(Mr. Tassanai Suksukon)
Technical Manager



Page 1 of 3

Certificate No.: AD2108-102-0001

Environment: Ambient Temperature: $(25 \pm 2)^\circ\text{C}$
Relative Humidity: $(50 \pm 15)\%\text{RH}$

UUC Reading psi	STD Reading (psi) Before Adjusted	STD Reading (psi) After Adjusted	UUC Error psi	Uncertainty \pm psi
0.0	0.00	-	0.00	0.26
5.0	5.02	-	-0.02	0.26
10.0	10.00	-	0.00	0.26
15.0	15.02	-	-0.02	0.26
20.0	20.03	-	-0.03	0.26
25.0	25.01	-	-0.01	0.26
30.0	30.02	-	-0.02	0.26

STD = Standard

UUC = Unit Under Calibration

Calibrated condition: Pressure Medium: Air: Density = 1.19 kg/m^3 @ 20°C , 1 bar
Mounting Position: Vertical
Reference Level: at center of its dial
Conversion Factor: Multiply by $6.894757 \text{ E}+03$ - Pa unit

Description of UUC: Range: 0 - 30 psi
Calibration Range: 0 - 30 psi
Scale Interval: 1 psi
Resolution: 0.2 psi

Measurement Standards Used & Traceability:

The International System of Units (SI) through

MIT Certificate No. AD2105-007-0001, AD2105-007-0002, AD2105-007-0003 for Pressure Calibrator Druck DPI 610 Serial No. 6103324208, Due 20-May-22

End of Certificate

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INSTALLATION OF STATIONARY PUMPS FOR FIRE PROTECTION

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ADMINISTRATION

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NFPA 20

Standard for the

Installation of Stationary Pumps for Fire Protection

2016 Edition

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex D. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex D.

Chapter 1 Administration

- 1.1* Scope.**
- 1.1.1 This standard deals with the selection and installation of pumps supplying liquid for private fire protection.
- 1.1.2 The scope of this document shall include liquid supplies, suction, discharge, and auxiliary equipment; power supply, including power supply arrangements, electric drive and control; diesel engine drive and control; steam turbine drive and control; and acceptance tests and operation.
- 1.1.3 This standard does not cover system liquid supply capacity and pressure requirements, nor does it cover requirements for periodic inspection, testing, and maintenance of fire pump systems.

1.1.4 This standard does not cover the requirements for installation wiring of fire pump units.

1.2 Purpose. The purpose of this standard is to provide a reasonable degree of protection for life and property from fire through installation requirements for stationary pumps for fire protection based upon sound engineering principles, test data, and field experience.

1.3 Application.

1.3.1 This standard shall apply to centrifugal single-stage and multistage pumps of the horizontal or vertical shaft design and positive displacement pumps of the horizontal or vertical shaft design.

1.3.2 Requirements are established for the design and installation of single-stage and multistage pumps, pump drivers, and associated equipment.

1.4 Retrospectivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retrospectively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Units.

1.6.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

1.6.2 *Libre and for* in this standard are outside of but recognized by SI.

1.6.3 Units are listed in Table 1.6.3 with conversion factors.

1.6.4 Conversion. The conversion procedure is to multiply the quantity by the conversion factor and then round the result to an appropriate number of significant digits.

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GENERAL REQUIREMENTS

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pressure in the suction piping, while monitoring pressure in the suction piping through a sensing line.

3.3.67.3 Pressure Control Valve. A photo-operated pressure-reducing valve designed for the purpose of reducing the downstream water pressure to a specific value under both flowing (residual) and nonflowing (static) conditions. [14, 2013]

3.3.67.4 Pressure-Reducing Valve. A valve designed for the purpose of reducing the downstream water pressure under both flowing (residual) and nonflowing (static) conditions. [14, 2013]

3.3.67.5 Relief Valve. A device that allows the diversion of liquid to limit excess pressure in a system.

3.3.67.5.1 Circulation Relief Valve. A valve used to cool a pump by discharging a small quantity of water. This valve is separate from and independent of the main relief valve.

3.3.67.6 Unloader Valve. A valve that is designed to relieve excess flow below pump capacity at set pump pressure.

3.3.68 Variable Speed Pressure Limiting Control. A speed control system used to limit the total discharge pressure by reducing the pump driver speed from rated speed.

3.3.69 Variable Speed Suction Limiting Control. A speed control system used to maintain a minimum positive suction pressure at the pump inlet by reducing the pump driver speed while monitoring pressure in the suction piping through a sensing line.

3.3.70 Velocity Head (h_v). See 3.3.25.6.

3.3.71 Wet Pit. A timber, concrete, or masonry enclosure having a screened inlet kept partially filled with water by an open body of water such as a pond, lake, or stream.

Chapter 4 General Requirements

4.1 Pumps. This standard shall apply to centrifugal single-stage and multistage pumps of the horizontal or vertical shaft design and positive displacement pumps of the horizontal or vertical shaft design.

4.2* Approval Required.

4.2.1 Stationary pumps shall be selected based on the conditions under which they are to be installed and used.

4.2.2 The pump manufacturer or its authorized representative shall be given complete information concerning the liquid and power supply characteristics.

4.2.3 A complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and liquid supply conditions shall be prepared for approval.

4.2.3.1 Plans shall be drawn to an indicated scale, on sheets of uniform size, and shall indicate, as a minimum, the items from the following list that pertain to the design of the system:

- (1) Name(s) of owner and occupant
- (2) Location, including street address
- (3) Point of compass
- (4) Name and address of installing contractor
- (5) Pump make and model number

- (6) Pump rating — gpm @ — psi — rpm
- (7) Suction main size, length, location, type and class/schedule of material, and point of connection to water supply, as well as depth to top of pipe below grade
- (8) Water storage tank, if applicable
- (9) Size and type of valves, regulators, meters, and valve pits, if applicable
- (10) Water supply information including the following flow test information, if applicable:

- (a) Location and elevation of static and residual test gauge with relation to the elevation reference point
- (b) Flow location
- (c) Static pressure, psi (bar)
- (d) Residual pressure, psi (bar)
- (e) Flow, gpm (L/min)
- (f) Date
- (g) Time
- (h) Name of person who conducted the test or supplied the information
- (i) Other sources of water supply, with pressure or elevation

- (11) Other sources of water supply, with pressure or elevation
- (12) Pump driver details including manufacturer and horsepower
- (13) Voltage for electric motor-driven pumps
- (14) Fuel system details for diesel-driven pumps
- (15) Controller manufacturer, type, and rating
- (16) Suction and discharge pipe, fitting, and valve types
- (17) Test connection piping and valves
- (18) Flow meter details, if applicable
- (19) Pressure maintenance pump and controller arrangement including sensing line details, if applicable

4.2.4 Each pump, driver, controlling equipment, power supply and arrangement, and liquid supply shall be approved by the authority having jurisdiction for the specific field conditions encountered.

4.3 Pump Operation.

4.3.1 In the event of fire pump operation, qualified personnel shall respond to the fire pump location to determine that the fire pump is operating in a satisfactory manner.

4.3.2 System Design.

4.3.2.1 The system designer shall be identified on the system design documents.

4.3.2.2 Acceptable minimum evidence of qualifications or certification shall be provided when requested by the authority having jurisdiction.

4.3.2.3 Qualified personnel shall include, but not be limited to, one or more of the following:

- (1) Personnel who are factory trained and certified for fire pump system design of the specific type and brand of system being designed
- (2) Personnel who are certified by a nationally recognized fire protection certification organization acceptable to the authority having jurisdiction
- (3) Personnel who are registered, licensed, or certified by a state or local authority

4.3.2.4 Additional evidence of qualification or certification shall be permitted to be required by the AHJ.

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GENERAL REQUIREMENTS

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buildings or rooms enclosing electric fire pump drivers shall be protected with an automatic sprinkler system installed in accordance with NFPA 13 as an Ordinary Hazard Group 1 occupancy.

4.13.2 Equipment Access.

4.13.2.1 The location of and access to the fire pump room(s) shall be pre-planned with the fire department.

4.13.2.1.1 Except as provided in 4.13.2.1.1.1, fire pump rooms not directly accessible from the outside shall be accessible through an enclosed passageway from an enclosed stairway or exterior exit.

4.13.2.1.1.1 Fire pump units supplying only local application fire protection systems shall be accessible by a path that is not subject to exposure from a fire in any hazard protected by the fire pump.

4.13.2.1.2 The enclosed passageway shall have a fire-resistance rating not less than the fire-resistance rating of the fire pump room.

4.13.3 Heat.

4.13.3.1 An approved or listed source of heat shall be provided for maintaining the temperature of a pump room or pump house, where required, above 40°F (4°C).

4.13.3.2 The requirements of 4.13.3 shall be followed for higher temperature requirements for internal combustion engines.

4.13.4 Normal Lighting. Artificial light shall be provided in a pump room or pump house.

4.13.5 Emergency Lighting.

4.13.5.1 Pump rooms shall be provided with emergency lighting.

4.13.5.2 The intensity of illumination in the pump room(s) shall be 3.0 foot-candles (32.3 lux), unless otherwise specified by a requirement recognized by the authority having jurisdiction.

4.13.5.3 Emergency lights shall not be connected to an engine-starting battery.

4.13.5.4 The emergency lighting shall be capable of maintaining the lighting level for a minimum of 2 hours.

4.13.6 Ventilation. Provision shall be made for ventilation of a pump room or pump house.

4.13.7 Drainage.

4.13.7.1 Floors shall be pitched for adequate drainage of escaping water away from critical equipment such as the pump, driver, controller, and so forth.

4.13.7.2 The pump room or pump house shall be provided with a floor drain that will discharge to a frost-free location.

4.13.8 Guards. Couplings and flexible connecting shafts shall be installed with a coupling guard in accordance with Section 7 of ANSI B11.19, *Performance Requirements for Safeguarding*.

4.14 Pipe and Fittings.

4.14.1 Steel Pipe.

4.14.1.1 Steel pipe shall be used aboveground except for connection to underground suction and underground discharge piping.

4.14.1.2 Where corrosive water conditions exist, steel suction pipe shall be galvanized or painted on the inside prior to installation with a paint recommended for submerged surfaces.

4.14.1.3 Thick bituminous linings shall not be used.

4.14.2 Joining Method.

4.14.2.1 Sections of steel piping shall be joined by means of screwed, flanged mechanical grooved joints or other approved fittings.

4.14.2.2 Slip-type fittings shall be permitted to be used where installed as required by 4.15.6 and where the piping is mechanically secured to prevent slippage.

4.14.3 Concentrate and Additive Piping.

4.14.3.1 From concentrate or additive piping shall be a material that will not corrode in this service.

4.14.3.2 Galvanized pipe shall not be used for foam concentrate service.

4.14.4 Drain Piping. Drain pipe and its fittings that discharge to atmosphere shall be permitted to be constructed of metallic or polymeric materials.

4.14.5 Piping, Hangers, and Seismic Bracing.

4.14.5.1 The support of pipe and fittings shall comply with the requirements of 9.1 and 9.2 in NFPA 13.

4.14.5.2 The seismic protection, where applicable, of pipe and fittings shall comply with the requirements of 9.3 in NFPA 13.

4.14.6 Cutting and Welding. Torch cutting or welding in the pump house shall be permitted as a means of modifying or repairing pump house piping when it is performed in accordance with NFPA 51B.

4.15 Suction Pipe and Fittings.

4.15.1 Components.

4.15.1.1 The suction components shall consist of all pipe, valves, and fittings from the pump suction flange to the connection to the public or private water service main, storage tank, or reservoir, and so forth, that feeds water to the pump.

4.15.1.2 Where pumps are installed in series, the suction pipe for the subsequent pump(s) shall begin at the system side of the discharge valve of the previous pump.

4.15.1.3 Installation. Suction pipe shall be installed and tested in accordance with NFPA 21.

4.15.2 Suction Size.

4.15.2.1 Unless the requirements of 4.15.3.2 are met, the size of the suction pipe for a single pump or of the suction header pipe for multiple pumps (designed to operate together) shall be such that, with all pumps operating at maximum flow (150 percent of rated capacity or the maximum flow available from the water supply as discussed in 4.15.3.1), the gauge pressure at the pump suction flanges shall be 0 psi (0 bar) or higher.

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sure at the pump suction flanges shall be 0 psi (0 bar) or higher.

4.15.3.2 The requirements of 4.15.3.1 not apply where the supply is a suction tank with its base at or above the same elevation as the pump, and the gauge pressure at the pump suction flange shall be permitted to drop to 3 psi (0.2 bar) with the lowest water level after the maximum system demand and duration have been supplied.

4.15.3.3 The size of that portion of the suction pipe located within 10 pipe diameters upstream of the pump suction flange shall be not less than that specified in Section 4.27.

4.15.4 Pumps with Bypass.

4.15.4.1 Where the suction supply is of sufficient pressure to be of material value without the pump, the pump shall be installed with a bypass. (See Figure A.4.15.4.1.)

4.15.4.2 For multistage multipump, a bypass shall be installed between the pump suction and the first outlet port and between sequential outlet ports wherever the bypass can provide pressure that is of material value without the impeller. (See Figure A.4.15.4.2.)

4.15.4.3 The size of the bypass shall be at least as large as the pipe size required for discharge pipe as specified in Section 4.27.

4.15.5 Valves.

4.15.5.1 A listed outside screw and yoke (OS&Y) gate valve shall be installed in the suction pipe.

4.15.5.2 No control valve other than a listed OS&Y valve and the devices as permitted in 4.28.3 shall be installed in the suction pipe within 50 ft (15.3 m) of the pump suction flange.

4.15.6 Installation.

4.15.6.1 General. Suction pipe shall be laid carefully to avoid air leaks and air pockets, either of which can seriously affect the operation of the pump.

4.15.6.2 Freeze Protection.

4.15.6.2.1 Suction pipe shall be installed below the frost line or in frostproof casings.

4.15.6.2.2 Where pipe enters streams, ponds, or reservoirs, special attention shall be given to prevent freezing either underground or underwater.

4.15.6.3 Elbows and Tees.

4.15.6.3.1 Unless the requirements of 4.15.6.3.2 are met, elbows and tees with a centerline plane parallel to a horizontal splice-pump shaft shall not be permitted. (See Figure A.4.15.6.3.)

4.15.6.3.2 The requirements of 4.15.6.3.1 shall not apply to elbows and tees with a centerline plane parallel to a horizontal splice-pump shaft where the distance between the flanges of the pump suction intake and the elbow and tee is greater than 10 times the suction pipe diameter.

4.15.6.3.3 Elbows and tees with a centerline plane perpendicular to the horizontal splice-pump shaft shall be permitted at any location in the pump suction intake.

4.15.6.4 Eccentric Tapered Reducer or Increases. Where the suction pipe and pump suction flange are not of the same size, they shall be connected with an eccentric tapered reducer or increase installed in such a way as to avoid air pockets.

4.15.6.5 Strain Relief. Where the pump and its suction supply are on separate foundations with rigid interconnecting pipe, the pipe shall be provided with strain relief. (See Figure A.6.3.1(a).)

4.15.7 Multiple Pumps. Where a single suction pipe supplies more than one pump, the suction pipe layout at the pumps shall be arranged so that each pump will receive its proportional supply.

4.15.8 Suction Screening.

4.15.8.1 Where the water supply is obtained from an open source such as a pond or wet pit, the passage of materials that might clog the pump shall be obstructed.

4.15.8.2 Double intake screens shall be provided at the suction intake.

4.15.8.3 Screens shall be removable, or an in situ cleaning shall be provided.

4.15.8.4 Below minimum water level, these screens shall have an effective net area of opening of 1 in.² for each 1 gpm (170 mm³ for each 1 L/min) at 150 percent of rated pump capacity.

4.15.8.5 Screens shall be so arranged that they can be cleaned or repaired without disturbing the suction pipe.

4.15.8.6 Mesh screens shall be brass, copper, Monel, stainless steel, or other equivalent corrosion-resistant metallic material wire screen of 0.50 in. (12.7 mm) maximum mesh and No. 10 B&S gauge.

4.15.8.7 Where flat panel mesh screens are used, the wire shall be secured to a metal frame sliding vertically at the entrance to the intake.

4.15.8.8 Where the screens are located in a sump or depression, they shall be equipped with a debris-sliding rail.

4.15.8.9 Periodically, the system shall be test pumped, the screens shall be removed for inspection, and accumulated debris shall be removed.

4.15.8.10 Continuous slot screens shall be brass, copper, Monel, stainless steel, or other equivalent corrosion-resistant metallic material of 0.125 in. (3.2 mm) maximum slot and profile wire construction.

4.15.8.11 Screens shall have at least 62.5 percent open area.

4.15.8.12 Where a mesh screen is not present or reasonably anticipated at the site, the screens shall be constructed of a material with demonstrated resistance to debris mesh attachment or coated with a material with demonstrated resistance to debris mesh attachment at low velocities.

4.15.8.13 The overall area of the screen shall be 1.6 times the net screen opening area. (See *Screen Area* in Figure A.7.2.2.2.)

4.15.9 Devices in Suction Piping.

4.15.9.1 No device or assembly, unless identified in 4.15.9.2, that will stop, restrict the starting of, or restrict the discharge of

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a fire pump or pump driver shall be installed in the suction piping.

4.15.9.2 The following devices shall be permitted in the suction piping where the following requirements are met:

- (1) Check valves and backflow prevention devices and assemblies shall be permitted where required by other NFPA standards or the authority having jurisdiction and installed in accordance with Section 4.25.
- (2) Where the authority having jurisdiction requires positive pressure to be maintained on the suction piping, a pressure-sensing line for a low suction pressure control, specifically listed for fire pump service, shall be permitted to be connected to the suction piping.
- (3) Devices shall be permitted to be installed in the suction piping or stored water supply and arranged to activate a signal if the pump suction pressure or water level falls below a predetermined minimum.
- (4) Suction strainers shall be permitted to be installed in the suction piping where required by other sections of this standard.
- (5) Other devices specifically permitted or required by this standard shall be permitted.

4.15.10 Anti-Vortex Plate. Where a tank is used as the suction source for a fire pump, the discharge outlet of the tank shall be equipped with an assembly that controls vortex flow in accordance with NFPA 22.

4.16 Discharge Pipe and Fittings.

4.16.1 The discharge components shall consist of pipe, valves, and fittings extending from the pump discharge flange to the system side of the discharge valve.

4.16.2 For multistage multipump, the discharge components for each port shall consist of pipe, valves, and fittings extending from the pump port discharge flange to the system side of the discharge valve for that port.

4.16.3 The pressure rating of the discharge components shall be adequate for the maximum total discharge head with the pump operating at shutoff and rated speed but shall not be less than the rating of the fire protection system.

4.16.4 Steel pipe with flanges, screwed joints, or mechanical grooved joints shall be used above ground.

4.16.5 All pump discharge pipe shall be hydrostatically tested in accordance with NFPA 15.

4.16.6 The size of pump discharge pipe and fittings shall not be less than that given in Section 4.27.

4.16.7 A listed check valve or backflow preventer shall be installed in the pump discharge assembly.

4.16.8 A listed indicating gate or butterfly valve shall be installed on the fire protection system side of the pump discharge check valve.

4.16.9 Where pumps are installed in series, a butterfly valve shall not be installed between pumps.

4.16.10 Low Suction Pressure Controls.

4.16.10.1 Suction pressure regulating valves that are listed for fire pump service and that are suction pressure sensitive shall be permitted where the authority having jurisdiction requires positive pressure to be maintained on the suction piping.

4.16.10.2 Where a suction pressure regulating valve is used, it shall be installed according to manufacturers' recommendations in the piping between the pump and the discharge check valve.

4.16.10.3 The size of the suction pressure regulating valve shall not be less than that given for discharge piping in Section 4.27.

4.16.10.4 The friction loss through a suction pressure regulating valve in the fully open position shall be taken into account in the design of the fire protection system.

4.16.10.5 System design shall be such that the suction pressure regulating valve is in the fully open position at the system design point and at 100 percent of rated flow.

4.16.11 Pressure Regulating Devices. No pressure regulating devices shall be installed in the discharge pipe except as permitted in this standard.

4.17 Valve Supervision.

4.17.1 Supervised Open. Where provided, the suction valve, discharge valve, bypass valve, and isolation valves on the backflow prevention device or assembly shall be supervised open by one of the following methods:

- (1) Central station, proprietary, or remote station signaling service
- (2) Local signaling service that will cause the sounding of an audible signal or a constantly attended point
- (3) Locking valves open

4.17.2 Supervised Closed. Control valves located in the pipe line to the hose valve header shall be supervised closed by one of the methods allowed in 4.17.1.

4.18 Protection of Piping Against Damage Due to Movement. A clearance shall be provided around pipes that pass through walls, ceilings, or floors of the fire pump room enclosure.

4.18.1 Unless the requirements of 4.18.2 through 4.18.4 are met, where pipe passes through walls, ceilings, or floors of the fire pump room enclosure, the holes shall be sized such that the diameter of the hole is nominally 2 in. (50 mm) larger than the pipe.

4.18.2 Where clearance is provided by a pipe sleeve, a nominal diameter 2 in. (50 mm) larger than the nominal diameter of the pipe shall be acceptable.

4.18.3 No clearance is required if flexible couplings are located within 1 ft (305 mm) of each side of the wall, ceiling, or floor.

4.18.4 Where protection of piping against damage caused by earthquakes is required, the provisions of Section 4.29 shall apply.

4.18.5 Where required, the clearance shall be filled with flexible material that is compatible with the piping materials and maintains any required fire resistance rating of the enclosure.

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4.19 Relief Valves for Centrifugal Pumps.

4.19.1 General.

4.19.1.1 Pressure relief valves shall be used only where specifically permitted by this standard.

4.19.1.2 Where a diesel engine fire pump is installed and where a total of 121 percent of the net rated shutoff (churn) pressure plus the maximum static suction pressure, adjusted for elevation, exceeds the pressure for which the system components are rated, a pressure relief valve shall be installed.

4.19.1.3 Where an electric variable speed pressure limiting controller or a diesel pressure limiting device is installed, and the maximum total discharge head adjusted for elevation with the pump operating at shutoff and rated speed exceeds the pressure rating of the system components, a pressure relief valve shall be installed.

4.19.1.4 Where a variable speed pressure limiting control is used, the pressure relief valve shall be set to a minimum of 10 psi (0.68 bar) above the set pressure of the variable speed pressure limiting control.

4.19.1.5 The relief valve size shall be determined by one of the methods specified in 4.19.2.1 or 4.19.2.2.

4.19.2.1 The relief valve shall be permitted to be sized hydraulically to discharge sufficient water to prevent the pump discharge pressure, adjusted for elevation, from exceeding the pressure rating of the system components.

4.19.2.2 If the relief valve is not sized hydraulically, the relief valve size shall not be less than that given in Section 4.27. (See also 4.19.7 and A.4.19.7 for conditions that affect size.)

4.19.3 Location. The relief valve shall be located between the pump and the pump discharge check valve and shall be so attached that it can be readily removed for repairs without disturbing the piping.

4.19.4 Type.

4.19.4.1 Pressure relief valves shall be either a listed spring-loaded or a pilot-operated diaphragm type.

4.19.4.2 Pilot-operated pressure relief valves, where attached to vertical shaft turbine pumps, shall be arranged to prevent reflecting of water at water pressures less than the pressure relief setting of the valve.

4.19.5 Discharge.

4.19.5.1 The relief valve discharge shall be to an open pipe or into a cone or funnel vented to the outlet of the valve.

4.19.5.2 Water discharge from the relief valve shall be readily visible or easily detectable by the pump operator.

4.19.5.3 Splashing of water into the pump room shall be avoided.

4.19.5.4 If a closed-type cone is used, it shall be provided with means for detecting motion of water through the cone.

4.19.5.5 If the relief valve is provided with means for detecting motion (flow) of water through the valve, then cones or funnels at its outlet shall not be required.

4.19.6 Discharge Piping.

4.19.6.1 Except as permitted in 4.19.6.2, the relief valve discharge pipe shall be of a size not less than that given in Section 4.27.

4.19.6.2 The discharge pipe shall be permitted to be sized hydraulically to discharge sufficient water to prevent the pump discharge pressure, adjusted for elevation, from exceeding the pressure rating of the system components.

4.19.6.3 If the pipe employs more than one elbow, the next larger pipe size shall be used.

4.19.6.3.1 Relief valve discharge piping returning water back to the supply source, such as an aboveground storage tank, shall be run independently and not be combined with the discharge from other relief valves.

4.19.6.7 Discharge to Source of Supply. Where the relief valve is piped back to the source of supply, the relief valve and piping shall have sufficient capacity to prevent pressure from exceeding that for which system components are rated.

4.19.7.1 Where a pressure relief valve has been piped back to suction, a circulation relief valve sized in accordance with 4.12.1.7 and 4.19.7 and discharged to atmosphere shall be provided downstream of the pressure relief valve. The circulation relief valve shall actuate before the opening set point of the pressure relief valve to ensure cooling of the pump during churn operation.

4.19.7.2 Where pump discharge water is piped back to pump suction and the pump is driven by a diesel engine with heat exchanger cooling, the controller shall provide a visual indicator and audible alarm and stop the engine when a high cooling water temperature signal as required by 11.2.4.1.8 is received, provided there are no active emergency requirements for the pump to run.

4.19.7.2.1 The requirements of 4.19.7.2 shall not apply when pump discharge water is being piped back to a water storage reservoir.

4.19.8 Discharge to Suction Reservoir. Where the supply of water to the pump is taken from a suction reservoir of limited capacity, the drain pipe shall discharge into the reservoir at a point as far from the pump suction as is necessary to prevent the pump from drafting air introduced by the drain pipe discharge.

4.19.9 Shutoff Valve. A shutoff valve shall not be installed in the relief valve supply or discharge piping.

4.20 Pumps Arranged in Series.

4.20.1 Series Fire Pump Unit Performance.

4.20.1.1 A series fire pump unit (pumps, drivers, controllers, and accessories) shall perform in compliance with this standard as an entire unit.

4.20.1.2 Within 30 seconds after a demand to start, pumps in series shall supply and maintain a stable discharge pressure (± 10 percent) throughout the entire range of operation.

4.20.1.2.1 The discharge pressure shall be permitted to stabilize whenever the flow condition changes.

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4.20.1.3 The complete series fire pump unit shall be field acceptance tested for proper performance in accordance with the provisions of this standard. (See Section 4.2.2.)

4.20.2 Series Fire Pump Unit Arrangement.

4.20.2.1* Except as permitted by 4.20.2.2, all the pumps that are a part of a series fire pump unit shall be located within the same fire pump room.

4.20.2.2 Pumps that are a part of a series fire pump unit shall be permitted to be located in separate pump rooms where all the following conditions are met:

- (1) Each pump shall be arranged so that all pumps operating in series can be manually stopped or started from all pump rooms housing the series fire pumps.
- (2) The suction and discharge pressures from all pumps operating in series shall be announced in the other pump rooms for all pumps that are a part of the series fire pump unit in accordance with 4.20.2.8 and 4.20.2.9.
- (3) The interconnect control wiring between the controllers in different pump rooms shall comply with 4.20.2.8 and 4.20.2.9.
- (4) A pump room communication system shall comply with 4.20.2.9 and 4.20.2.10.

4.20.2.3 No more than three pumps shall be allowed to operate in series as a part of a series fire pump unit.

4.20.2.4 No more than two variable speed pumps shall be allowed to operate in series as a part of a series fire pump unit.

4.20.2.5 No pump in a series pump unit shall be shut down automatically for any condition of suction pressure.

4.20.2.6 No pressure reducing or pressure regulating valves shall be installed between fire pumps arranged in series as a part of a series fire pump unit.

4.20.2.7 The pressure at any point in any pump in a series fire pump unit, with all pumps running at shutoff and rated speed at the maximum static suction supply, shall not exceed any pump suction, discharge, or case working pressure rating.

4.20.2.8 Protection of Control Wiring for Series Fire Pump Units.

4.20.2.8.1* Interconnected control wiring of fire pumps in series that are not located in the same room and that affect the starting of the supply (lower zone) pump(s) shall be protected against fire and physical damage in the same manner as power conductors described in NFPA 70, Article 605.

4.20.2.8.1.1 The motor on the supply (lower zone) pump(s) shall start on the opening of the control circuit (remote start) loop.

4.20.2.8.1.2 The installed controllers shall meet the requirements of 10.5.2.5 or 12.7.2.5 as applicable.

4.20.2.9 Status Signals for Series Fire Pump Units.

4.20.2.9.1 Audible and visual status signals shall be provided in each pump room indicating the status of the associated series pump(s) not located in the same pump room.

4.20.2.9.1.1 The following audible and visual signals shall be provided in each pump room for each series electric fire pump(s):

- (1) Pump running in accordance with 10.4.7.2.1
- (2) Phase loss in accordance with 10.4.7.2.2
- (3) Phase reversal in accordance with 10.4.7.2.3
- (4) Controller connected to alternative source in accordance with 10.4.7.2.4
- (5) Alternate circuit breaker open or tripped in accordance with 10.8.3.12.1
- (6) Low suction pressure — suction pressure more than 10 psi (0.68 bar) below the design suction pressure on any downstream series pump(s).

4.20.2.9.1.2 The following audible and visual signals shall be provided in each pump room for each series diesel fire pump(s):

- (1) Pump running in accordance with 12.4.2.3(1)
- (2) Control switch in off or manual position in accordance with 12.4.2.3(2)
- (3) Trouble on controller or engine in accordance with 12.4.2.3(3)
- (4) Low suction pressure — suction pressure more than 10 psi (0.68 bar) below the design suction pressure on any downstream series pump(s).

4.20.2.9.2 Series fire pump controller(s) shall be provided with additional contact for remote indication in accordance with 4.20.2.9.1.1 or 4.20.2.9.1.2.

4.20.2.9.2.1 Where other means are used to communicate this information, additional contacts in 4.20.2.9.2 shall not be required.

4.20.2.10 Communications for Series Fire Pump Units.

4.20.2.10.1 A two-way, in-building emergency services communications system in accordance with NFPA 72 shall be provided in each pump room where pumps in series are not located in the same room.

4.20.2.10.1.1 The communication system shall meet the survivability requirements of NFPA 72.

4.21 Water Flow Test Devices.**4.21.1 General.**

4.21.1.1* A fire pump installation shall be arranged to allow the test of the pump at its rated conditions as well as the suction supply at the maximum flow available from the fire pump.

4.21.1.2* Where water usage or discharge is not permitted for the duration of the test specified in Chapter 14, the outlet shall be used to test the pump and suction supply and determine that the system is operating in accordance with the design.

4.21.1.3 The flow shall continue until the flow has stabilized. (See 11.2.6.5.)

4.21.1.4 Where a test header is installed, it shall be installed on an exterior wall or in another location outside the pump room that allows for water discharge during testing.

4.21.2 Meters and Testing Devices.

4.21.2.1* Metering devices or fixed nozzles for pump testing shall be listed.

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4.21.2.2 Metering devices or fixed nozzles shall be capable of water flow of not less than 175 percent of rated pump capacity.

4.21.2.3 All of the meter system piping shall be permitted to be sized hydraulically but shall not be smaller than as specified by the meter manufacturer.

4.21.2.4 If the meter system piping is not sized hydraulically, then all of the meter system piping shall be sized as specified by the meter manufacturer but not less than the meter device sizes shown in Section 4.27.

4.21.2.5 For nonhydraulically sized piping, the minimum size meter for a given pump capacity shall be permitted to be used where the meter system piping does not exceed 100 ft (30.5 m) equivalent length.

4.21.2.6 For nonhydraulically sized piping, where meter system piping exceeds 100 ft (30.5 m), including length of straight pipe plus equivalent length in fittings, elevation, and loss through meter, the next larger size of piping shall be used to minimize friction loss.

4.21.2.7 The primary element shall be suitable for that pipe size and pump rating.

4.21.2.8 The readout instrument shall be sized for the pump rated capacity. (See Section 4.27.)

4.21.2.9 When discharging back into a tank, the discharge nozzle(s) or pipe shall be located at a point as far from the pump section as is necessary to prevent the pump from drawing air introduced by the discharge of test water into the tank.

4.21.2.10* Where a metering device is installed in a loop arrangement for fire pump flow testing, an alternate means of measuring flow shall be provided.

4.21.2.10.1 The alternate means of measuring flow shall be located downstream of and in series with the flow meter.

4.21.2.10.2 The alternate means of measuring flow shall function for the range of flows necessary to conduct a full flow test.

4.21.2.10.3 An appropriately sized test header shall be an acceptable alternate means of measuring flow.

4.21.3 Hose Valves.**4.21.3.1* General.**

4.21.3.1.1 Hose valves shall be listed.

4.21.3.1.2 The number and size of hose valves used for pump testing shall be as specified in Section 4.27.

4.21.3.1.3 Where outlets are being utilized as a means to test the fire pump in accordance with 4.21.1.1, one of the following methods shall be used:

- (1) Hose valves mounted on a hose valve header with supply pipe sized in accordance with 4.21.3.4 and Section 4.27
- (2) Wall hydrants, yard hydrants, or standpipe outlets of sufficient size and size to allow testing of the pump

4.21.3.1.3.1 Thread Type. Thread types shall be in compliance with one of the following:

- (1) Hose valves shall have the NH standard external thread for the valve size specified, as stipulated in NFPA 1663.
- (2) Where local fire department connections do not conform to NFPA 1663 and the connection is to be utilized as a

will hydrant, the authority having jurisdiction shall designate the threads to be used.

4.21.3.3 Location.

4.21.3.3.1 A listed indicating butterfly or gate valve shall be located in the pipeline to the hose valve header.

4.21.3.3.2 A chain valve or automatic ball dip shall be located in the pipeline at a low point between the valve and the header. (See Figure A.6.3.1(a) and Figure A.7.2.2.1.)

4.21.3.3.3 The valve required in 4.21.3.3.1 shall be at a point in the line close to the pump. (See Figure A.6.3.1(a).)

4.21.3.4 Pipe Size. The pipe size shall be in accordance with one of the following two methods:

- (1) Where the pipe between the hose valve header and the connection to the pump discharge pipe is over 15 ft (4.5 m) in length, the next larger pipe size than that required by 4.21.3.1.3 shall be used.
- (2) This pipe is permitted to be sized by hydraulic calculations based on a total flow of 150 percent of rated pump capacity, including the following:
 - (a) This calculation shall include friction loss for the total length of pipe plus equivalent lengths of fittings, control valve, and hose valves, plus elevation loss, from the pump discharge flange to the hose valve outlets.
 - (b) The installation shall be proven by a test flowing the maximum water available.

4.22 Steam Power Supply Dependability.**4.22.1 Steam Supply.**

4.22.1.1 Careful consideration shall be given in each case to the dependability of the steam supply and the steam supply system.

4.22.1.2 Consideration shall include the possible effect of interruption of transmission pipeline on the property or in adjoining buildings that could threaten the property.

4.23 Shop Tests.

4.23.1 General. Each individual pump shall be tested at the factory to provide detailed performance data and to demonstrate its compliance with specifications.

4.23.2 Preshipment Tests.

4.23.2.1 Before shipment from the factory, each pump shall be hydraulically tested by the manufacturer for a period of not less than 5 minutes.

4.23.2.2 The test pressure shall not be less than one and one-half times the sum of the pump's shutoff head plus its maximum allowable suction head, but in no case shall it be less than 250 psi (17.2 bar).

4.23.2.3 Pump casings shall be essentially tight at the test pressure.

4.23.2.4 During the test, no objectionable leakage shall occur at any joint.

4.23.2.5 In the case of vertical turbine-type pumps, both the discharge casing and pump bowl assembly shall be tested.

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4.24.1* Pump Shaft Rotation. Pump shaft rotation shall be determined and correctly specified when fire pumps and equipment involving that rotation are ordered.

4.25* Other Signals. Where required by other sections of this standard, signals shall call attention to improper conditions in the fire pump equipment.

4.26* Pressure Maintenance (Jockey or Make-Up) Pumps.

4.26.1 For pressure-maintained fire pumps, a means to maintain the pressure in the fire protection system shall be provided in accordance with one of the following:

- (1) A pressure maintenance (jockey) pump
- (2) A water meter displacement pumping unit in accordance with 8.5.7.2
- (3) Another approved means that is not the main fire pump

4.26.2 Pressure maintenance pumps shall not be required to be listed. Pressure maintenance pumps shall be approved.

4.26.2.1* The pressure maintenance pump shall be sized to replenish the fire protection system pressure due to allowable leakage and normal drops in pressure.

4.26.3 Pressure maintenance pumps shall have rated capacities not less than any normal leakage rate.

4.26.4 Pressure maintenance pumps shall have discharge pressure sufficient to maintain the desired fire protection system pressure.

4.26.5* Excess Pressure.

4.26.5.1 Where a centrifugal-type pressure maintenance pump has a total discharge pressure with the pump operating at shutoff of exceeding the working pressure rating of the fire protection equipment, or where a turbine vane (peripheral) type of pump is used, a relief valve sized to prevent overpressure of the system shall be installed on the pump discharge to prevent damage to the fire protection system.

4.26.5.2 Running period timers shall not be used where jockey pumps are utilized that have the capability of exceeding the working pressure of the fire protection systems.

4.26.6 Piping and Components for Pressure Maintenance Pumps.

4.26.6.1 Steel pipe shall be used for suction and discharge piping on pressure maintenance pumps, which includes packaged prefabricated systems.

4.26.6.2 Valves and components for the pressure maintenance pump shall not be required to be listed.

4.26.6.3 An isolation valve shall be installed on the suction side of the pressure maintenance pump to isolate the pump for repair.

4.26.6.4 A check valve and isolation valve shall be installed in the discharge pipe.

4.26.6.5 Indicating valves shall be installed in such places as needed to make the pump, check valve, and miscellaneous fittings accessible for repair.

4.26.6.6 The pressure sensing line for the pressure maintenance pump shall be in accordance with Section 4.31.

4.26.6.7 The isolation valves serving the pressure maintenance pump shall not be required to be supervised.

4.26.7 Except as permitted in Chapter 8, the primary or standby fire pump shall not be used as a pressure maintenance pump.

4.26.8 The controller for a pressure maintenance pump shall be listed but shall not be required to be listed for fire pump service.

4.26.9 The pressure maintenance pump shall not be required to have secondary or standby power.

4.27 Summary of Centrifugal Fire Pump Data. The sizes indicated in Table 4.27(a) and Table 4.27(b) shall be used as a minimum.**4.28 Backflow Preventers and Check Valves.**

4.28.1 Check valves and backflow prevention devices and assemblies shall be listed for fire protection service.

4.28.2 Relief Valve Drainage.

4.28.2.1 Where the backflow prevention device or assembly incorporates a relief valve, the relief valve shall discharge to a drain appropriately sized for the maximum anticipated flow from the relief valve.

4.28.2.2 An air gap shall be provided in accordance with the manufacturer's recommendations.

4.28.2.3 Water discharge from the relief valve shall be readily visible or easily detectable.

4.28.2.4 Performance of the requirements in 4.28.2.1 through 4.28.2.3 shall be documented by engineering calculations and tests.

4.28.3 Devices in Suction Piping. Where located in the suction pipe of the pump, check valves and backflow prevention devices or assemblies shall be located a minimum of 10 pipe diameters from the pump suction flange.

4.28.3.1 Where a backflow preventer with butterfly control valves is installed in the suction pipe, the backflow preventer is required to be at least 50 ft (15.2 m) from the pump suction flange (as measured along the route of pipe) in accordance with 4.15.5.2.

4.28.4 Evaluation.

4.28.4.1 Where the authority having jurisdiction requires the installation of a backflow prevention device or assembly in connection with the pump, special consideration shall be given to the increased pressure loss resulting from the installation.

4.28.4.2 Where a backflow prevention device is installed, the final arrangement shall provide effective pump performance with a minimum pump suction pressure of 0 psi (0 bar) at the gauge at 150 percent of rated capacity.

4.28.4.3 If available suction supplies do not permit the flowing of 150 percent of rated pump capacity, the final arrangement of the backflow prevention device shall provide effective pump performance with a minimum suction pressure of 0 psi (0 bar) at the gauge at the maximum allowable discharge.

4.28.4.4 The discharge shall exceed the fire protection system design flow.

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Table 4.27(a) Summary of Centrifugal Fire Pump Data (U.S. Customary)

Pump Rating (gpm)	Minimum Pipe Sizes (Nominal) (in.)					Number and Size of Hose Valves	Hose Header Supply
	Suction ^{a,b}	Discharge ^a	Relief Valve Discharge	Relief Valve Meter Device	Relief Valve Meter Device		
25	1	1	1/2	1	1 1/2	1 — 1 1/2	1
50	1 1/2	1 1/2	1 1/2	1 1/2	2	1 — 1 1/2	1 1/2
100	2	2	2	2	2 1/2	1 — 2 1/2	2 1/2
150	2 1/2	2 1/2	2 1/2	2 1/2	3	1 — 2 1/2	2 1/2
200	3	3	3	3	3	1 — 2 1/2	2 1/2
250	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	1 — 2 1/2	3
300	4	4	4	4	4	1 — 2 1/2	3
400	4	4	4	4	4	2 — 2 1/2	4
450	5	5	5	5	5	2 — 2 1/2	4
500	5	5	5	5	5	2 — 2 1/2	4
750	6	6	6	6	6	3 — 2 1/2	6
1000	8	8	8	8	8	4 — 2 1/2	6
1250	8	8	8	8	8	6 — 2 1/2	8
1500	8	8	8	8	8	6 — 2 1/2	8
2000	10	10	10	10	10	6 — 2 1/2	8
2500	10	10	10	10	10	8 — 2 1/2	10
3000	12	12	12	12	12	12 — 2 1/2	10
3500	12	12	12	12	12	12 — 2 1/2	12
4000	14	14	14	14	14	16 — 2 1/2	12
4500	16	16	16	16	16	16 — 2 1/2	12
5000	16	16	16	16	16	20 — 2 1/2	12

Notes:

(1) The pressure relief valve is permitted to be sized in accordance with 4.19.2.1.

(2) The pressure relief valve discharge is permitted to be sized in accordance with 4.19.6.2.

(3) The flowmeter device is permitted to be sized in accordance with 4.21.3.3.

(4) The hose header supply is permitted to be sized in accordance with 4.21.3.4.

^aActual diameter of pump flange is permitted to be different from pipe diameter.

^bApplies only to that portion of suction pipe specified in 4.15.5.3.

^cSuction pipe sizes in Table 4.27(a) are based on a maximum velocity at 150 percent rated capacity to 15 ft/sec (4.6 m/sec) in most cases.

4.28.4.5 Determination of effective pump performance shall be documented by engineering calculations and tests.

4.28.4.6 Retrospective installation of a backflow prevention device shall not reduce the suction pressure below that permitted in this standard and accepted by the authority having jurisdiction.

4.28.4.7 Retrospective installation of a backflow prevention device shall not result in a discharge pressure that does not meet the maximum system demand.

4.29 Earthquake Protection.

4.29.1 General. Where water-based fire protection systems to be protected against damage from earthquakes, 4.29.2 and 4.29.3 shall apply.

4.29.2 Seismic Loads. Horizontal seismic loads shall be determined in accordance with NFPA 13: SEI/ASCE 7, Minimum Design Loads for Buildings and Other Structures, local, state, or international codes, or other sources acceptable to the authority having jurisdiction.

4.29.3 Components.

4.29.3.1 Pump Driver and Controller. The fire pump, driver, and fire pump controller shall be attached to their foundations with materials capable of resisting applicable seismic loads.

4.29.3.2* High Center of Gravity. Pumps with high centers of gravity, such as vertical turbine pumps, shall be mounted at their base and braced above their center of gravity.

4.29.3.3* Pipe and Fittings. Pipe and fittings shall be protected in accordance with NFPA 13.

4.29.3.4 Apertures. Seismic protection of apertures, including trim pieces, shall be required where they are essential for post-earthquake operation of the fire pump.

4.29.3.4.1* Where seismically protecting smaller diameter trim lines, restraint shall be sufficient.

4.30 Packaged Fire Pump Assemblies.

4.30.1 A packaged fire pump assembly, with or without an enclosure, shall meet all of the following requirements:

- (1) The components shall be assembled and affixed onto a steel framing structure.

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Table 4.27(b) Summary of Centrifugal Fire Pump Data (Metric)

Pump Rating (L/min)	Minimum Pipe Sizes (Nominal) (mm)					
	Suction ^{a,b,c}	Discharge ^a	Relief Valve	Relief Valve Discharge	Motor Device	Hose Header Supply
95	25	25	19	25	32	1-38
189	38	32	32	38	50	1-38
379	50	50	38	50	65	1-65
568	65	65	50	65	75	1-65
757	75	75	50	65	75	1-65
946	85	75	50	65	85	1-65
1,136	100	100	65	85	85	1-65
1,514	100	100	75	125	100	2-65
1,703	125	125	75	125	100	2-65
1,992	125	125	75	125	125	2-65
2,839	150	150	100	150	125	3-65
3,785	200	150	100	200	150	4-65
4,731	200	200	150	200	150	6-65
5,677	200	200	150	200	200	6-65
7,570	250	250	150	250	200	6-65
9,462	250	250	150	250	200	8-65
11,355	300	300	200	300	200	12-65
13,247	300	300	200	300	250	12-65
15,140	350	300	200	350	250	16-65
17,032	400	350	200	350	250	16-65
18,925	400	350	200	350	250	20-65

Notes:
(1) The pressure relief valve is permitted to be sized in accordance with 4.19.2.1.
(2) The pressure relief valve discharge is permitted to be sized in accordance with 4.19.2.2.
(3) The flow meter device is permitted to be sized in accordance with 4.21.2.3.
(4) The hose header supply is permitted to be sized in accordance with 4.21.3.1.
(5) Actual diameter of pump flange is permitted to be different from nominal size.
*Applies only to that portion of suction pipe specified in 4.15.3.3.
^aSuction pipe size in Table 4.27(b) are based on a maximum velocity at 150 percent rated capacity to 15 ft/sec (4.6 m/sec) in most cases.

- (2) Welders shall be qualified in accordance with the Section 9 of ASME *Boiler and Pressure Vessel Code* or with the American Welding Society AWS D11.1, *Structural Welding Code—Steel*.
(3) The assembly shall be listed for fire pump service.
(4) The total assembly shall be engineered and designed by a system designer as referenced in 4.3.2.
(5) All plans and data sheets shall be submitted and reviewed by the authority having jurisdiction, with copies of the stamped approved submittals used in the assembly and for record keeping.

4.30.2 All electrical components, clearances, and wiring shall meet the minimum requirements of the applicable NFPA 70 articles.

4.30.3 Packaged and prefabricated skid unit(s) shall meet all the requirements in this standard, including those described in Sections 4.13 through 4.18.

4.30.4 Careful consideration shall be given to the possible effects of system component damage during shipment to the project site.

4.30.4.1 The structural integrity shall be maintained with minimal flexing and movement.

4.30.4.2 The necessary supports and restraints shall be installed to prevent damage and leakage during transit.

4.30.5 The packaged fire pump shall have the correct lifting points marked to ensure safe rigging of the unit.

4.30.6 All packaged pump house or pump skids, or both, shall meet the requirements of Section 4.29.

4.30.7 Suction and discharge piping shall be thoroughly inspected, including checking all flanged and mechanical connections per manufacturer's recommendations, after the pump house or skid unit is set in place on the permanent foundation.

4.30.8 The units shall be properly anchored and grouted in accordance with Section 6.4.

4.30.9 The interior floor of a package pump house shall be of solid construction with grading to provide proper drainage for the fire pump components.

4.30.9.1 The interior floor shall be permitted to be provided with grouting in accordance with 4.30.8 or installed after the

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packaged pump house is set in place in accordance with 4.30.10.

4.30.9.2 The structural frame for a packaged pump house shall be mounted on an engineered footing designed to withstand the live loads of the packaged unit and the applicable wind loading requirements.

4.30.9.3 The foundation footings of a package pump house shall include the necessary anchor points required to secure the package to the foundation.

4.30.10 A highly abrasion-resistant, solid structural plate floor with grout holes shall be permitted to be used where protection from corrosion and drainage is provided for all incidental pump room spillage or leakage.

4.31* Pressure-Actuated Controller Pressure Sensing Lines.

4.31.1 For all pump installations, including jockey pumps, each controller shall have its own individual pressure sensing line.

4.31.1.1 Every multistage multipump pump for each discharge port shall have its own individual pressure sensing line connected to the fire pump controller.

4.31.1.1.1 The pressure maintenance pump controller for each discharge port shall have its own individual pressure sensing line.

4.31.2 The pressure sensing line connection for each pump, including jockey pumps, shall be made between that pump's discharge check valve and discharge isolation valve.

4.31.3* The pressure sensing line shall be brass, rigid copper pipe Types K, L, or M, or Series 300 stainless steel pipe or tube, and the fittings shall be of 1/2 in. (13 mm) nominal size.

4.31.4 Check Valves or Ground-Face Unions.

4.31.4.1 Where the requirements of 4.31.4.2 are not met, two bronze or stainless steel check valves shall be installed in the pressure sensing line at least 5 ft (1.52 m) apart with a nominal 1/2 in. (2.4 mm) hole drilled in the bronze or stainless steel check valve to serve as dampening. (See Figure A.4.31(a) and Figure A.4.31(b).)

4.31.4.2 Where the water is clean, ground-face unions with noncorrosive diaphragms drilled with a nominal 1/2 in. (2.4 mm) orifice shall be permitted in place of the check valves.

4.31.4.3 There shall be two inspection test valves attached to the pressure sensing line that shall consist of a tee, a valve, a second tee with the branch plugged, and a second valve. (See Figure A.4.31(a) and Figure A.4.31(b).)

4.31.5 Shutoff Valves. There shall be no shutoff valve in the pressure sensing line.

4.31.6 Pressure Switch Actuation. Pressure switch actuation at the low adjustment setting shall initiate the pump starting sequence (if the pump is not already in operation).

4.32 Break Tanks. Where a break tank is used to provide the pump station water supply, the installation shall comply with NFPA 22.

4.33 Field Acceptance Test of Pump Units. Upon completion of the entire fire pump installation, an acceptance test shall be

conducted in accordance with the provisions of this standard. (See Chapter 11.)

Chapter 5 Fire Pumps for High-Rise Buildings

5.1 General.

5.1.1 Application.

5.1.1.1 This chapter applies to all fire pumps within a building wherever a building is defined as high-rise in accordance with 3.3.26.

5.1.1.2 The provisions of all other chapters of this standard shall apply unless specifically addressed by this chapter.

5.2* Equipment Access. Location and access to the fire pump room shall be preplanned with the fire department.

5.3 Water Supply Tanks.

5.3.1 Where provided, water tanks shall be installed in accordance with NFPA 22.

5.3.2 When a water tank serves domestic and fire protection systems, the domestic supply connection shall be connected above the level required for fire protection demand.

5.4 Fire Pump Test Arrangement. Where the water supply to a fire pump is a tank, a listed flowmeter or a test header discharging back into the tank with a calibrated nozzle(s) arranged for the attachment of a pressure gauge to determine pilot pressure shall be required.

5.5 Auxiliary Power. Where electric motor-driven fire pump(s) are used, a reliable emergency source of power in accordance with Section 5.6 or a backup fire pump in accordance with Section 9.3 shall be provided for the fire pump installation.

5.6* Very Tall Buildings.

5.6.1 Water Supply Tanks for Very Tall Buildings.

5.6.1.1 Where the primary supply source is a tank, two or more water tanks shall be provided.

5.6.1.1.1 A water tank shall be permitted to be divided into compartments such that the compartments function as individual tanks.

5.6.1.1.2 The total volume of all tanks or compartments shall be sufficient for the full fire protection demand.

5.6.1.1.3 Each individual tank or compartment shall be sized so that at least 50 percent of the fire protection demand is stored with any one compartment or tank out of service.

5.6.1.2 An automatic refill valve shall be provided for each tank or tank compartment.

5.6.1.3 A manual refill valve shall be provided for each tank or tank compartment.

5.6.1.4 Each refill valve shall be sized and arranged to independently supply the system fire protection demand.

5.6.1.5 The automatic and manual fill valve combination for each tank or tank compartment shall have its own connection to one of the following:

- 1) A standpipe riser that is supplied with a backup fire pump

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- (2) A reliable domestic riser sized to meet the requirements of 5.6.1.4.

5.6.1.5.1* Each connection shall be made to a different riser.

5.6.2 Fire Pump Backup. Fire pump serving zones that are partially or wholly beyond the pumping capability of the fire department apparatus shall be provided with one of the following:

- 1) A fully independent and automatic backup fire pump unit(s) arranged so that all zones can be maintained in full service with any one pump out of service.
- 2) An auxiliary means that is capable of providing the full fire protection demand and that is acceptable to the authority having jurisdiction.

Chapter 6 Centrifugal Pumps

6.1 General.

6.1.1* Types.

6.1.1.1 Centrifugal pumps shall be of the overhung impeller design and the impeller between bearings design.

6.1.1.2 The overhung impeller design shall be close coupled or separately coupled single- or two-stage end-suction-type (see Figure A.6.1.1(a) and Figure A.6.1.1(b)) or inline-type (see Figure A.6.1.1(c) through Figure A.6.1.1(f)) pumps.

6.1.1.3 The impeller between bearings design shall be separately coupled single-stage or multistage axial (horizontal) split-case type (see Figure A.6.1.1(g)) or radial (vertical) split-case type (see Figure A.6.1.1(h)).

6.1.2* Application. Centrifugal pumps shall not be used where a static suction lift is required.

6.2* Factory and Field Performance.

6.2.1 Pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. (See Figure A.6.2.)

6.2.1.1 Each discharge outlet in a multistage multipump pump shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. (See Figure A.6.2.)

6.2.2 The shutoff head shall not exceed 140 percent of rated head for any type pump. (See Figure A.6.2.)

6.2.2.1 For each discharge outlet in a multistage multipump pump, the shutoff head shall not exceed 140 percent of rated head for any type pump. (See Figure A.6.2.)

6.3 Fittings.

6.3.1* Where necessary, the following fittings for the pump shall be provided by the pump manufacturer or an authorized representative:

- 1) Automatic air release valve
 - 2) Circulation relief valve
 - 3) Pressure gauges
- 6.3.2 Where necessary, the following fittings shall be provided:
- 1) Eccentric tapered reducer at suction inlet
 - 2) Hose valve manifold with hose valves
 - 3) Flow measuring device
 - 4) Relief valve and discharge cone

- (5) Pipeline strainer

6.3.3 Automatic Air Release.

6.3.3.1 Unless the requirements of 6.3.3.2 are met, pumps that are automatically controlled shall be provided with a listed float-operated air release valve having a nominal 0.50 in. (12.7 mm) minimum diameter discharge to atmosphere.

6.3.3.2 The requirements of 6.3.3.1 shall not apply to overhung impeller-type pumps with top centrifugal discharge or that are vertically mounted to naturally vent the air.

6.4 Foundation and Setting.

6.4.1* Overhung impeller and impeller between bearings design pumps and driver shall be mounted on a common grouted base plate.

6.4.2 Pumps of the overhung impeller close coupled inline type (see Figure A.6.1.1(c)) shall be permitted to be mounted on a base attached to the pump mounting base plate.

6.4.3 The base plate shall be securely attached to a solid foundation in such a way that pump and driver alignment is ensured.

6.4.4* The foundation shall be sufficiently substantial to form a permanent and rigid support for the base plate.

6.4.5 The base plate, with pump and driver mounted on it, shall be set level on the foundation.

6.5* Connection to Driver and Alignment.

6.5.1 Coupling Type.

6.5.1.1 Separately coupled-type pumps with electric motor or diesel engine drivers shall be connected by a flexible coupling or flexible connecting shaft.

6.5.1.2* Flexible couplings and flexible connecting shafts shall be listed for fire pump service and installed in accordance with the listing.

6.5.2 Pumps and drivers on separately coupled-type pumps shall be aligned in accordance with the coupling and pump manufacturers' specifications and the *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*. (See A.6.3.)

Chapter 7 Vertical Shaft Turbine-Type Pumps

7.1* General.

7.1.1* Application. Where the water supply is located below the discharge (large centerline) and the water supply pressure is insufficient to deliver the water to the fire pump, a vertical shaft turbine-type pump shall be used.

7.1.2 Factory and Field Performance.

7.1.2.1 Pumps shall furnish not less than 150 percent of rated capacity at a total head of not less than 65 percent of the total rated head. (See Figure 7.1.2.)

7.1.2.2 The total shutoff head shall not exceed 140 percent of the total rated head on vertical turbine pumps. (See Figure A.6.2.)

7.1.2.3 The vertical turbine-type pump shall be designed to operate in a vertical position with all parts in correct alignment.

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7.2 Water Supply.

7.2.1* Source.

7.2.1.1* The water supply shall be adequate, dependable, and acceptable to the authority having jurisdiction.

7.2.1.2* The acceptance of a well as a water supply source shall be dependent upon satisfactory development of the well and establishment of satisfactory aquifer characteristics.

7.2.2 Pump Submergence.

7.2.2.1 Well Installations.

7.2.2.1.1 Submergence of the pump bowls shall be provided for reliable operation of the fire pump unit.

7.2.2.1.2 Submergence of the second impeller from the bottom of the pump bowl assembly shall be not less than 10 ft (3.0 m) below the pumping water level at 150 percent of rated capacity. (See Figure 7.2.2.1.)

7.2.2.1.3* The submergence shall be increased by 1 ft (0.3 m) for each 100 ft (30.5 m) of elevation above sea level.

7.2.2.2* Wet Pit Installations.

7.2.2.2.1 To provide submergence for priming, the elevation of the second impeller from the bottom of the pump bowl assembly shall be such that it is below the lowest pumping water level in the open body of water supplying the pit.

7.2.2.2.2 For pumps with rated capacities of 2000 gpm (7570 L/min) or greater, additional submergence is required to prevent the formation of vortices and to provide required net positive suction head (NPSH) in order to prevent excessive cavitation.

7.2.2.2.3 The required submergence shall be obtained from the pump manufacturer.

7.2.2.2.4 The distance between the bottom of the strainer and the bottom of the wet pit shall be at least one-half of the pump bowl diameter but not less than 12 in. (303 mm).

7.2.3 Well Construction.

7.2.3.1 It shall be the responsibility of the groundwater supply contractor to perform the necessary groundwater investigation to establish the reliability of the supply, to develop a well to produce the required supply, and to perform all work and install all equipment in a thorough and workmanlike manner.

7.2.3.2 To support the requirements of 7.2.3.1, the well shall be of a pump diameter and sufficiently plain to receive the pump.

7.2.4 Unconsolidated Formations (Sands and Gravels).

7.2.4.1 All casings shall be of steel of such diameter and installed to such depths as the formation could justify and as best meet the conditions.

7.2.4.2 Both inner and outer casings shall have a minimum wall thickness of 0.375 in. (9.5 mm).

7.2.4.3 Inner casing diameter shall be not less than 2 in. (51 mm) larger than the pump bowls.

7.2.4.4 The outer casing shall extend down to approximately the top of the water-bearing formation.

7.2.4.5 The inner casing of lesser diameter and the well screen shall extend as far into the formation as the water-bearing stratum could justify and as best meet the conditions.

7.2.4.6 The well screen is a vital part of the construction, and careful attention shall be given to its selection.

7.2.4.7 The well screen shall be the same diameter as the inner casing and of the proper length and percent open area to provide an entrance velocity not exceeding 0.15 ft/sec (46 mm/sec).

7.2.4.8 The screen shall be made of a corrosion- and acid-resistant material, such as stainless steel or Monel.

7.2.4.9 Monel shall be used where it is anticipated that the chloride content of the well water will exceed 1000 parts per million.

7.2.4.10 The screen shall have adequate strength to resist the external forces that will be applied after it is installed and to minimize the likelihood of damage during the installation.

7.2.4.11 The bottom of the well screen shall be sealed properly with a plate of the same material as the screen.

7.2.4.12 The sides of the outer casing shall be sealed by the introduction of neat cement placed under pressure from the bottom to the top.

7.2.4.13 Cement shall be allowed to set for a minimum of 48 hours before drilling operations are continued.

7.2.4.14 The immediate area surrounding the well screen not less than 6 in. (152 mm) shall be filled with clean and well-graded gravel.

7.2.4.15 This gravel shall be of such size and quality as will create a gravel filter to ensure sand-free production and a low velocity of water leaving the formation and entering the well.

7.2.4.16 Tubular Wells.

7.2.4.16.1 Wells for fire pumps not exceeding 450 gpm (1703 L/min) developed in unconsolidated formations without artificial gravel pack, such as tubular wells, shall be acceptable sources of water supply for fire pumps not exceeding 450 gpm (1703 L/min).

7.2.4.16.2 Tubular wells shall comply with all the requirements of 7.2.3 and 7.2.4, except compliance with 7.2.4.11 through 7.2.4.15 shall not be required.

7.2.5* Consolidated Formations. Where the drilling penetrates consolidated formations above the rock, surface casing shall be installed, sealed in solid rock, and cemented in place.

7.2.6 Developing a Well.

7.2.6.1 Developing a new well and cleaning it of sand or rock particles (not to exceed 5 gpm) shall be the responsibility of the groundwater supply contractor.

7.2.6.2 Such development shall be performed with a test pump and not a fire pump.

7.2.6.3 Freedom from sand shall be determined when the test pump is operated at 150 percent of rated capacity of the fire pump for which the well is being prepared.

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7.2.7* Test and Inspection of Well.

7.2.7.1 A test to determine the water production of the well shall be made.

7.2.7.2 An acceptable water measuring device such as an orifice, a venturi meter, or a calibrated pitot tube shall be used.

7.2.7.3 The test shall be witnessed by a representative of the customer, contractor, and authority having jurisdiction, as required.

7.2.7.4 The test shall be continuous for a period of at least 8 hours at 150 percent of the rated capacity of the fire pump with 15-minute-interval readings over the period of the test.

7.2.7.5 The test shall be evaluated with consideration given to the effect of other wells in the vicinity and any possible seasonal variation in the water table at the well site.

7.2.7.6 Test data shall describe the static water level and the pumping water level at 100 percent and 150 percent, respectively, of the rated capacity of the fire pump for which the well is being prepared.

7.2.7.7 All existing wells within a 1000 ft (305 m) radius of the fire well shall be monitored throughout the test period.

7.3 Pump.

7.3.1* Vertical Turbine Pump Head Component.

7.3.1.1 The pump head shall be either the aboveground or belowground discharge type.

7.3.1.2 The pump head shall be designed to support the driver, pump, column assembly, hand assembly, maximum down thrust, and the full tension nut or packing container.

7.3.2 Column.

7.3.2.1* The pump column shall be furnished in sections not exceeding a nominal length of 10 ft (3 m), shall be not less than the weight specified in Table 7.3.2.1(a) and Table 7.3.2.1(b), and shall be connected by threaded-sleeve couplings or flanges.

7.3.2.2 The ends of each section of threaded pipe shall be faced parallel and machined with thrusts to permit the ends to butt so as to form accurate alignment of the pump column.

7.3.2.3 All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment.

Table 7.3.2.1(a) Pump Column Pipe Weights (U.S. Customary)

Nominal Size (in.)	Outside Diameter (O.D.) (in.)	Weight per Unit Length (lb/ft)
6	6.625	18.97
7	7.625	22.26
8	8.625	24.70
9	9.625	28.33
10	10.75	31.20
12	12.75	43.77
14	14.00	53.57

Table 7.3.2.1(b) Pump Column Pipe Weights (Metric)

Nominal Size (mm)	Outside Diameter (O.D.) (mm)	Weight per Unit Length (kg/m)
150	161	28.29
200	212	36.78
250	264	46.41
300	315	63.17
350	360	81.29

7.3.2.4 Where the static water level exceeds 50 ft (15.3 m) below ground, oil-lubricated-type pumps shall be used. (See Figure A.7.1.1.1.)

7.3.2.5 Where the pump is of the enclosed line shaft oil-lubricated type, the shaft-enclosing tube shall be furnished in interchangeable sections not over 10 ft (3 m) in length of extra-strength pipe.

7.3.2.6 An automatic sight feed oiler shall be provided on a suitable mounting bracket with connection to the shaft tube for oil-lubricated pumps. (See Figure A.7.1.1.1.)

7.3.2.7 The pump line shafting shall be sized so critical speed shall be 25 percent above and below the operating speed of the pump.

7.3.2.8 Operating speed shall include all speeds from shutoff to the 150 percent point of the pump, which vary on engine drives.

7.3.2.9 Operating speed for variable speed pressure limiting control drive systems shall include all speeds from limit to minimum operating speed.

7.3.3 Bowl Assembly.

7.3.3.1 The pump bowl shall be of close-grained cast iron, bronze, or other suitable material in accordance with the chemical analysis of the water and experience in the area.

7.3.3.2 Impellers shall be of the enclosed type and shall be of bronze or other suitable material in accordance with the chemical analysis of the water and experience in the area.

7.3.4 Section Strainer.

7.3.4.1 A cast or heavy fabricated, corrosion-resistant metal cone or basket-type strainer shall be attached to the suction manifold of the pump.

7.3.4.2 The suction strainer shall have a free area of at least four times the area of the suction connections, and the openings shall be sized to restrict the passage of a 0.5 in. (12.7 mm) sphere.

7.3.4.3 For installations in a wet pit, this suction strainer shall be required in addition to the intake screen. (See Figure A.7.2.2.2.)

7.3.5 Fittings.

7.3.5.1 The following fittings shall be required for attachment to the pump:

- (1) Automatic air release valve as specified in 7.3.5.2
- (2) Water level detector as specified in 7.3.5.3
- (3) Discharge pressure gauge as specified in 4.11.1

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- (1) Relief valve and discharge cone where required by 4.19.1
- (5) Flow valve header and flow valve as specified in 4.21.3 or metering devices as specified in 4.21.2

7.3.5.2 Automatic Air Release.

7.3.5.2.1 A nominal 1.5 in. (38 mm) pipe size or larger automatic air release valve shall be provided to vent air from the column and the discharge head upon the starting of the pump.

7.3.5.2.2 This valve shall also admit air to the column to displace the vacuum upon stopping of the pump.

7.3.5.2.3 This valve shall be located at the highest point in the discharge line between the fire pump and the discharge check valve.

7.3.5.3* Water Level Detection. Water level detection shall be required for all vertical turbine pumps installed in wells to monitor the suction pressure available at the shutoff, 100 percent flow, and 150 percent flow points, to determine if the pump is operating within its design conditions.

7.3.5.3.1 Each well installation shall be equipped with a suitable water level detector.

7.3.5.3.2 If an air line is used, it shall be brass, copper, or series 300 stainless steel.

7.3.5.3.3 Air lines shall be strapped to column pipe at 10 ft (3 m) intervals.

7.4* Installation.

7.4.1 Pump House.

7.4.1.1 The pump house shall be of such design as will offer the least obstruction to the convenient handling and hoisting of vertical pump parts.

7.4.1.2 The requirements of Sections 4.13 and 11.3 shall also apply.

7.4.2 Outdoor Setting.

7.4.2.1 If in special cases the authority having jurisdiction does not require a pump room and the unit is installed outdoors, the driver shall be screened or enclosed and protected against tampering.

7.4.2.2 The screen or enclosure required in 7.4.2.1 shall be easily removable and shall have provision for ample ventilation.

7.4.3 Foundation.

7.4.3.1 Certified dimension prints shall be obtained from the manufacturer.

7.4.3.2 The foundation for vertical pumps shall be built to carry the entire weight of the pump and driver plus the weight of the water contained in it.

7.4.3.3 Foundation bolts shall be provided to firmly anchor the pump to the foundation.

7.4.3.4 The foundation shall be of sufficient area and strength that the load per square inch (square millimeter) on concrete does not exceed design standards.

7.4.3.5 The top of the foundation shall be carefully leveled to permit the pump to hang freely over a well pit on a short-coupled pump.

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7.4.3.6 On a well pump, the pump head shall be positioned plumb over the well, which is not necessarily level.

7.4.3.7 Sump or Pit.

7.4.3.7.1 Where the pump is mounted over a sump or pit, beams shall be permitted to be used.

7.4.3.7.2 Where a right-angle gear is used, the driver shall be installed parallel to the beams.

7.5 Driver.

7.5.1 Method of Drive.

7.5.1.1 The driver provided shall be so constructed that the total thrust of the pump, which includes the weight of the shaft, impellers, and hydraulic thrust, can be carried on a thrust bearing of ample capacity so that it will have an average life rating of 5 years continuous operation.

7.5.1.2 All drivers shall be so constructed that axial adjustment of impellers can be made to permit proper installation and operation of the equipment.

7.5.1.3 Vertical shaft turbine pumps shall be driven by a vertical hollow shaft electric motor or vertical hollow shaft right-angle gear drive with diesel engine or steam turbine except as permitted in 7.5.1.4.

7.5.1.4 The requirements of 7.5.1.3 shall not apply to diesel engines and steam turbines designed and listed for vertical installation with vertical shaft turbine-type pumps, which shall be permitted to employ solid shafts and shall not require a right-angle gear drive but shall require a nonreversing ratchet.

7.5.1.5 Motors shall be of the vertical hollow-shaft type and comply with 9.5.1.9.

7.5.1.6 Mass Elastic System.

7.5.1.6.1 For drive systems that include a right angle gear drive, the pump manufacturer shall provide a complete mass elastic system torsional analysis to ensure there are no damaging stresses or critical speeds within 25 percent above and below the operating speed of the pump and driver.

7.5.1.6.2 The torsional analysis specified in 7.5.1.6.1 shall include the mass elastic characteristics for a wetted pump with the specific impeller trim, coupling, right-angle gear, flexible connecting shaft, and engine, plus the excitation characteristics of the engine.

7.5.1.6.3 For variable speed vertical hollow shaft electric motors, the pump manufacturer shall provide a complete mass elastic system torsional analysis to ensure there are no damaging stresses or critical speeds within 25 percent above and below the operating speed of the pump and driver.

7.5.1.6.4 For vertical turbine pumps using angle gear drives driven by a diesel engine, a torsional vibration damping type coupling shall be used and mounted on the engine side of the driver shaft.

7.5.1.6.4.1 The torsional vibration damping type coupling shall be permitted to be omitted when a mass elastic system torsional analysis is provided and accepted by the authority having jurisdiction.

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7.5.1.7* Gear Drives.

7.5.1.7.1 Gear drives and flexible connecting shafts shall be acceptable to the authority having jurisdiction.

7.5.1.7.2 Gear drives shall be of the vertical hollow-shaft type, permitting adjustment of the impellers for proper installation and operation of the equipment.

7.5.1.7.3 The gear drive shall be equipped with a nonreversing ratchet.

7.5.1.7.4 All gear drives shall be listed and rated by the manufacturer at a load equal to the maximum horsepower and thrust of the pump for which the gear drive is intended.

7.5.1.7.5 Watercooled gear drives shall be equipped with a visual means to determine whether water circulation is occurring.

7.5.1.8 Flexible Connecting Shafts.

7.5.1.8.1 Unless the requirements of 7.5.1.4 are met, engines shall be connected to vertical shaft pumps by means of a right-angle gear drive with a listed flexible connecting shaft, which will prevent undue strain on both the engine and the gear drive.

7.5.1.8.2 The flexible connecting shaft shall be listed for this diesel fire pump service.

7.5.1.8.3 The operating angle for the flexible connecting shaft shall not exceed the limits specified by the manufacturer for the speed and horsepower transmitted under any static or operating conditions.

7.5.1.8.4 The requirements of 7.5.1.8.1 shall not apply to diesel engines and steam turbines designed and listed for vertical installation with vertical shaft turbine-type pumps, which shall be permitted to employ solid shafts, shall not require a right-angle drive, but shall require a nonreversing ratchet.

7.5.2 Controls. The controller for the motor, diesel engine, or steam turbine shall comply with specifications for either electric-drive controllers in Chapter 10 or engine drive controllers in Chapter 12.

7.5.3 Variable Speed Vertical Turbine Pumps.

7.5.3.1 The pump supplier shall inform the controller manufacturer of any and all critical resonant speeds within the operating speed range of the pump, which is from zero up to full speed.

7.5.3.2 When water-lubricated pumps with line shaft bearings are installed, the pump manufacturer shall inform the controller manufacturer of the maximum allowed time for water to reach the top bearing under the condition of the lowest anticipated water level of the well or reservoir.

7.6 Operation and Maintenance.

7.6.1 Operation.

7.6.1.1* Before the unit is started for the first time after installation, all field-installed electrical connections and discharge piping from the pump shall be checked.

7.6.1.2 With the top drive coupling removed, the drive shaft shall be centered in the top drive coupling for proper alignment and the motor shall be operated momentarily to ensure that it rotates in the proper direction.

7.6.1.3 With the top drive coupling reinstalled, the impellers shall be set for proper clearance according to the manufacturer's instructions.

7.6.1.4* With the precautions of 7.6.1.1 through 7.6.1.3 taken, the pump shall be started and allowed to run.

7.6.1.5 The operation shall be observed for vibration while running, with vibration limits according to the *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*.

7.6.1.6 The driver shall be observed for proper operation.

7.6.2 Maintenance.

7.6.2.1 The manufacturer's instructions shall be carefully followed in making repairs and dismantling and reassembling pumps.

7.6.2.2 When spare or replacement parts are ordered, the pump serial number stamped on the nameplate fastened to the pump head shall be included in order to make sure the proper parts are provided.

7.6.2.3 Ample head room and access for removal of the pump shall be maintained.

Chapter 8 Positive Displacement Pumps

8.1* General.

8.1.1 Types. Positive displacement pumps shall be as defined in 3.3.44.14.

8.1.2* Suitability.

8.1.2.1 The positive displacement-type pump shall be listed for the intended application.

8.1.2.2* The listing shall verify the characteristic performance curves for a given pump model.

8.1.3 Application.

8.1.3.1 Positive displacement pumps shall be permitted to pump liquids for fire protection applications.

8.1.3.2 The selected pump shall be appropriate for the viscosity of the liquid.

8.1.4 Pump Seals.

8.1.4.1 The seal type acceptable for positive displacement pumps shall be either mechanical or lip seal.

8.1.4.2 Packing shall not be used.

8.1.5* Pump Materials. Materials used in pump construction shall be selected based on the corrosion potential of the environment, fluids used, and operational conditions. (See 3.3.9 for corrosion-resistant materials.)

8.1.6 Dump Valve.

8.1.6.1 A dump valve shall be provided on all closed head systems to allow the positive displacement pump to bleed off excess pressure and achieve operating speed before subjecting the driver to full load.

8.1.6.2 The dump valve shall operate only for the duration necessary for the positive displacement pump to achieve operating speed.

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8.1.6.3 Dump Valve Control.

8.1.6.3.1 Automatic Operation. When an electrically operated dump valve is used, it shall be controlled by the positive displacement pump controller.

8.1.6.3.2 Manual Operation. Means shall be provided at the controller to ensure dump valve operation during manual start.

8.1.6.4 Dump valves shall be listed.

8.1.6.5 Dump valve discharge shall be permitted to be piped to the liquid supply tank, pump suction, drain, or liquid supply.

8.2 Foam Concentrate and Additive Pumps.

8.2.1 Additive Pumps. Additive pumps shall meet the requirements for foam concentrate pumps.

8.2.2* Net Positive Suction Head. Net positive suction head (NPSH) shall exceed the pump manufacturer's required NPSH plus 5 ft (1.52 m) of liquid.

8.2.3 Seal Materials. Seal materials shall be compatible with the foam concentrate or additive.

8.2.4* Dry Run. Foam concentrate pumps shall be capable of dry running for 10 minutes without damage.

8.2.5* Minimum Flow Rates. Pumps shall have foam concentrate flow rates to meet the maximum foam demand for their intended service.

8.2.6* Discharge Pressure. The discharge pressure of the pump shall exceed the maximum water pressure under any operating condition at the point of foam concentrate injection.

8.3 Water Mist System Pumps.

8.3.1* Positive displacement pumps for water shall have adequate capacities to meet the maximum system demand for their intended service.

8.3.2 NPSH shall exceed the pump manufacturer's required NPSH plus 5 ft (1.52 m) of liquid.

8.3.3 The inlet pressure to the pump shall not exceed the pump manufacturer's recommended inlet pressure.

8.3.4 When the pump output has the potential to exceed the system flow requirements, a means to relieve the excess flow such as an unloader valve or orifice shall be provided.

8.3.5 Where the pump is equipped with an unloader valve, it shall be in addition to the safety relief valve as outlined in 8.5.2.

8.4 Water Mist Positive Displacement Pumping Units.

8.4.1 Water mist positive displacement pumping units shall be dedicated to and listed as a unit for fire protection service.

8.4.2 Except as provided in 8.4.3 through 8.4.8, all the requirements of this standard shall apply.

8.4.3 Water mist positive displacement pumping units shall include pumps, driver(s), and controller as a complete operating unit.

8.4.4 The pump controller shall manage the performance of all pumps and drivers to provide continuous and smooth operation without intermittent pump cycling or discharge pressure varying by more than 10 percent during pump sequencing after rated pressure has been achieved.

8.4.5 Redundancy shall be built into the units such that failure of a line pressure sensor or primary control board will not prevent the system from functioning as intended.

8.4.6 Where provided with a variable speed control, failure of the variable speed control feature shall cause the controller to bypass and isolate the variable speed control system.

8.4.7 The unit controller shall be arranged so that each pump can be manually operated individually without opening the enclosure door.

8.4.8 The requirement in 10.3.4.3 shall apply to each individual motor and the entire unit.

8.5 Fittings.

8.5.1 Gauges. A compound suction gauge and a discharge pressure gauge shall be furnished.

8.5.2* General Information for Relief Valves.

8.5.2.1 All pumps shall be equipped with a listed safety relief valve capable of relieving 100 percent of the rated pump capacity at a pressure not exceeding 125 percent of the relief valve set pressure.

8.5.2.2 The pressure relief valve shall be set such that the pressure required to discharge the rated pump capacity is at or below the lowest rated pressure of any component.

8.5.2.3 The relief valve shall be installed on the pump discharge to prevent damage to the fire protection system.

8.5.3* Relief Valves for Foam Concentrate Pumps.

8.5.3.1 For foam concentrate pumps, safety relief valves shall be piped in one of the following ways:

- (1) Connection of the discharge from the safety relief valve in the foam concentrate tank(s).
- (2) Where there is a tank return line, connection of the discharge from the safety relief valve to this line leading back to the tank provided there is no valve of any kind between the relief valve and the foam concentrate tank(s).
- (3) Connection of the discharge from the safety relief valve to the pump suction piping if a means to prevent overheating is provided.

8.5.3.2 There shall be no valve between the outlet of the safety relief valve and its connection to the system.

8.5.4* Relief Valves for Water Mist Pumps.

8.5.4.1 Except as provided in 8.5.4.2, safety relief valves on positive displacement water mist pumps shall discharge to a drain or to a water supply at atmospheric pressure.

8.5.4.2 A safety relief valve shall be permitted to discharge into the pump suction where conditions meet both of the following:

- (1) A means is provided to prevent overheating.
- (2) The safety relief valve and pump driver are sized to accommodate the back pressure in the pump suction.

8.5.5* Suction Strainers.

8.5.5.1 Pumps shall be equipped with a removable and cleanable suction strainer installed at least 10 pipe diameters from the pump suction inlet.

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8.5.5.2 Suction strainer pressure drop shall be calculated to ensure that sufficient NPSH is available to the pump.

8.5.5.3 The net open area of the strainer shall be at least four times the area of the suction piping.

8.5.5.4 Strainer mesh size shall be in accordance with the pump manufacturer's recommendation.

8.5.6 Water Supply Protection. Design of the system shall include protection of potable water supplies and prevention of cross connection or contamination.

8.5.7 Pressure Maintenance.

8.5.7.1 Except as permitted in 8.5.7.2, the primary or standby fire pump shall not be used as a pressure maintenance pump.

8.5.7.2 Water mist positive displacement pumping units that are designed and listed to alternate pressure maintenance duty between two or more pumps with variable speed pressure limiting control, and that provide a supervisory signal whenever pressure maintenance is required more than two times in one hour, shall be permitted to maintain system pressure.

8.5.7.3 When in the pressure maintenance mode, water mist positive displacement pumping units used for pressure maintenance shall not provide more than half of the nozzle flow of the smallest system nozzle when the standby pressure is applied at the smallest nozzle.

8.5.7.4 A single sensing line shall be permitted to be used for a water mist positive displacement pumping unit controller where the unit also serves for pressure maintenance on a water mist system.

8.6 Pump Drivers.

8.6.1 The driver shall be sized for and have enough power to operate the pump and drive train at all design points.

8.6.2 Reduction Gears.

8.6.2.1 If a reduction gear is provided between the driver and the pump, it shall be listed for the intended use.

8.6.2.1.1 Reduction gears shall meet the requirements of AGMA 2001, *Cylindrical Wormgearing: Design and Inspection Methods*.

8.6.2.2 Gears shall be AGMA Class 7 or better, and pinions shall be AGMA Class 8 or better.

8.6.2.3 Bearings shall be in accordance with AGMA standards and applied for an L10 life of 15,000 hours.

8.6.2.4 For drive systems that include a gear case, the pump manufacturer shall provide a complete mass elastic system torsional analysis to ensure there are no damaging stresses or critical speeds within 25 percent above and below the operating speed of the pump(s) and driver.

8.6.2.4.1 For variable speed drives, the analysis of 8.6.2.4 shall include all speeds down to 25 percent below the lowest operating speed obtainable with the variable speed drive.

8.6.3 Common Drivers.

8.6.3.1 A single driver shall be permitted to drive more than one positive displacement pump.

8.6.3.2 Redundant pump systems shall not be permitted to share a common driver.

8.7* Controllers. See Section 8.1 and Chapters 10 and 12 for requirements for controllers.

8.8 Foundation and Setting.

8.8.1 The pump and driver shall be mounted on a common grouted base plate.

8.8.2 The base plate shall be securely attached to a solid foundation in such a way that proper pump and driver shaft alignment will be maintained.

8.8.3 The foundation shall provide a solid support for the base plate.

8.9 Driver Connection and Alignment.

8.9.1 The pump and driver shall be connected by a listed, closed coupled, flexible coupling or flange joint of belt drive coupling.

8.9.2 The coupling shall be selected to ensure that it is capable of transmitting the horsepower of the driver and does not exceed the manufacturer's maximum recommended horsepower and operating speed.

8.9.3 Pumps and drivers shall be aligned once final base plate placement is complete.

8.9.4 Alignment shall be in accordance with the coupling manufacturer's specifications.

8.9.5 The operating angle for the flexible coupling shall not exceed the recommended tolerances.

8.10 Flow Test Devices.

8.10.1 A positive displacement pump installation shall be arranged to allow the test of the pump at its rated conditions as well as the suction supply at the maximum flow available from the pump.

8.10.2 Additive pumping systems shall be equipped with a flow meter or orifice plate installed in a test loop back to the additive supply tank.

8.10.3 Water pumping systems shall be equipped with a flow meter or orifice plate installed in a test loop back to the water supply tank, inlet side of the water pump, or drain.

Chapter 9 Electric Drive for Pumps

9.1 General.

9.1.1 This chapter covers the minimum performance and testing requirements of the sources and transmission of electrical power to motors driving fire pumps.

9.1.2 This chapter also covers the minimum performance requirements of all intermediate equipment between the source(s) and the pump, including the motor(s) but excluding the electric fire pump controller, transfer switch, and accessories (see *Chapter 10*).

9.1.3 All electrical equipment and installation methods shall comply with NFPA 70, Article 695, and other applicable articles.

9.1.4* All power supplies shall be located and arranged to protect against damage by fire from within the premises and exposing hazards.

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9.1.5 All power supplies shall have the capacity to run the fire pump on a continuous basis.

9.1.6 All power supplies shall comply with the voltage drop requirements of Section 9.1.

9.1.7 Phase converters shall not be used to supply power to a fire pump.

9.1.8* Interruption.

9.1.8.1 No ground fault interruption means shall be installed in any fire pump control or power circuit.

9.1.8.2 No arc fault interruption means shall be installed in any fire pump control or power circuit.

9.2* Normal Power.

9.2.1 An electric motor-driven fire pump shall be provided with a normal source of power as a continuously available source.

9.2.2 The normal source of power required in 9.2.1 and its routing shall be arranged in accordance with one of the following:

- (1) Service connection dedicated to the fire pump installation.
- (2) On-site power production facility connection dedicated to the fire pump installation.
- (3) Dedicated feeder connection derived directly from the dedicated service to the fire pump installation.
- (4) As a feeder connection where all of the following conditions are met:
 - (a) The protected facility is part of a multibuilding campus-type arrangement.
 - (b) A backup source of power is provided from a source independent of the normal source of power.
 - (c) It is impractical to supply the normal source of power through the arrangement in 9.2.2(1), 9.2.2(2), or 9.2.2(3).
 - (d) The arrangement is acceptable to the authority having jurisdiction.
 - (e) The overcurrent protection device(s) in each disconnecting means is selectively coordinated with any other supply side overcurrent protective device(s).
- (5) Dedicated transformer connection directly from the service meeting the requirements of Article 695 of NFPA 70.

9.2.3 For fire pump installations using the arrangement in 9.2.2(1), 9.2.2(2), 9.2.2(3), or 9.2.2(5) for the normal source of power, no more than one disconnecting means and associated overcurrent protection device shall be installed in the power supply to the fire pump controller.

9.2.3.1 Where the disconnecting means permitted by 9.2.3 is installed, the disconnecting means shall meet all of the following requirements:

- (1) It shall be identified as being suitable for use as service equipment.
- (2) It shall be lockable in both the closed position and the open position.
- (3) It shall be located remote from other building disconnecting means.
- (4)* It shall be located remote from other fire pump source disconnecting means.

(5) It shall be marked "Fire Pump Disconnecting Means" in letters that are no less than 1 in. (25 mm) in height and that can be seen without having to open enclosure doors or covers.

9.2.3.2 Where the disconnecting means permitted by 9.2.3 is installed, a placard shall be placed adjacent to the fire pump controller stating the location of this disconnecting means and the location of any key needed to unlock the disconnect.

9.2.3.3 Where the disconnecting means permitted by 9.2.3 is installed, the disconnect shall be supervised in the closed position by one of the following methods:

- (1) Central station, proprietary, or remote station signal device.
- (2) Local signaling device that will cause the sounding of an audible signal at a constantly attended location.
- (3) Locking the disconnecting means in the closed position.
- (4) Where the disconnecting means is located within fenced enclosures or in buildings under the control of the meter, sealing the disconnecting means and performing approved weekly recorded inspections.

9.2.3.4 Where the overcurrent protection permitted by 9.2.3 is installed, the overcurrent protection device shall be rated to carry indefinitely the sum of the locked rotor current of the largest pump motor and the full-load current of all of the other pump motors and accessory equipment.

9.2.3.4.1 Alternatively, compliance with 9.2.3.4 shall be based on an assembly listed for fire pump service that complies with the following:

- (1) The overcurrent protection device shall not open within 2 minutes at 600 percent full-load current.
- (2) The overcurrent protection device shall not open with a restart transient of 24 times the full-load current.
- (3) The overcurrent protection device shall not open within 10 minutes at 300 percent full-load current.
- (4) The trip point for circuit breakers shall not be field adjustable.

9.2.3.4.2 Overcurrent Device Selection. An instantaneous trip circuit breaker shall be permitted in lieu of the overcurrent devices specified in 10.8.2.2(2) provided it is part of a transfer switch assembly listed for fire pump service and complies with 9.2.3.4.1.

9.3 Alternate Power.

9.3.1 Unless there is an installed power arrangement as described in 9.3.3, at least one alternate source of power shall be provided for high-rise buildings or where the height of the structure is beyond the pumping capacity of the fire department apparatus.

9.3.2* Other Sources. Except for an arrangement described in 9.3.3, at least one alternate source of power shall be provided where the normal source is not reliable.

9.3.3 An alternate source of power for the primary fire pump shall not be required where a backup engine-driven fire pump, backup steam turbine-driven fire pump, or backup electric motor-driven fire pump with independent power source meeting 9.2.2 is installed in accordance with this standard.

9.3.4 Where provided, the alternate source of power shall be supplied from one of the following sources:

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- (1) A generator installed in accordance with Section 9.6
- (2) One of the sources identified in 9.2.2(1), 9.2.2(3), 9.2.2(3), or 9.2.2(5) where the power is provided independent of the normal source of power

9.3.5 Where provided, the alternate supply shall be arranged so that the power to the fire pump is not disrupted when overhead lines are deenergized for fire department operations.

9.3.6 Two or more alternate sources. Where the alternate source consists of two or more sources of power and one of the sources is a dedicated feeder derived from a utility service separate from that used by the normal source, the disconnecting means, intercurrent protective device, and conductors shall not be required to meet the requirements of Section 9.2 and shall be permitted to be installed in accordance with NFPA 70.

9.4* Voltage Drop.

9.4.1 Unless the requirements of 9.4.2 or 9.4.3 are met, the voltage at the controller line terminals shall not drop more than 15 percent below normal (controller-rated voltage) under motor-starting conditions.

9.4.2 The requirements of 9.4.1 shall not apply to emergency-run mechanical starting (see 10.3.3.2).

9.4.3 The requirements of 9.4.1 shall not apply to the bypass mode of a variable speed pressure limiting control (see 10.10.1.1), provided a successful start can be demonstrated on the standby generator.

9.4.4 The voltage at the contactor(s) load terminals to which the motor is connected shall not drop more than 5 percent below the voltage rating of the motor when the motor is operating at 115 percent of the full-load current rating of the motor.

9.4.4.1 Wiring from the controller(s) to the pump motor shall be in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic conduit, Type LFNCB, listed Type MC cable with an impervious covering, or Type MI cable.

9.4.4.2 Electrical connections at motor terminal boxes shall be made with a listed means of connection.

9.4.4.3 Twist-on insulation-piercing type and soldered wire connectors shall not be permitted to be used for this purpose.

9.5 Motors.

9.5.1 General.

9.5.1.1 All motors shall comply with NEMA MG-1, *Motors and Generators*, and shall be marked as complying with NEMA Design B standards for three-phase motors or NEMA Design N or L standards for single-phase motors, and shall be specifically listed for fire pump service (see *Table 9.5.1.1(a)*, *Table 9.5.1.1(b)*, and *Table 9.5.1.1(c)*).

9.5.1.1.1 Single-phase motors shall be used only in across-the-line starting applications.

9.5.1.2 The requirements of 9.5.1.1 shall not apply to direct-current, high-voltage (over 600 V), large-horsepower (over 500 hp (373 kW)), single-phase, universal-type, or wound-rotor motors, which shall be permitted to be used where approved.

Table 9.5.1.1(a) Horsepower and Locked Rotor Current Motor Designation for Three-Phase NEMA Design B Motors

Rated Horsepower	Locked Rotor Current Three-Phase 230 V at 60 Hertz (A)*	Motor Designation (NEMA 70, Locked Rotor Indicating Code Letter) "F" to and Including
1	30	N
1½	40	M
2	50	L
3	64	K
5	92	H
7½	127	G
10	162	F
15	242	E
20	290	D
25	365	C
30	435	B
40	580	A
50	725	
60	870	G
75	1085	F
100	1450	E
125	1815	D
150	2170	C
200	2900	B
250	3650	A
300	4400	
350	5160	G
400	5900	F
450	6500	E
500	7250	D

*Locked rotor current values are maximums.

Table 9.5.1.1(b) Horsepower and Locked Rotor Current Motor Designation for Single-Phase NEMA Design N and L Motors

Rated Horsepower	Design N	Design L	Design N	Design L
½	20	—	12	—
¾	26	—	15	—
1	31	—	18	—
1½	45	—	25	—
2	61	—	35	—
3	89	—	45	—
5	—	—	65	—
7½	—	—	90	—
10	—	—	115	—
15	—	—	200	—
20	—	—	290	—

*Locked rotor current values are maximums.

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Table 9.5.1.1(c) Horsepower and Locked Rotor Current Motor Designation for Three-Phase, 580 V, 50 Hertz, NEMA Design B Motors

Rated Horsepower	Locked Rotor Current Three-Phase 580 V at 50 Hertz (A)*	Motor Designation (NEMA 70, Locked Rotor Indicating Code Letter) "F" to and Including
1	29	F
1½	27	N
2	34	M
3	43	L
5	61	K
7½	81	J
10	107	I
15	154	H
20	194	G
25	245	F
30	289	E
40	387	D
50	482	C
60	578	B
75	722	A
100	965	
125	1207	G
150	1441	F
200	1927	E
250	2534	D
300	3026	C
350	3512	B
400	4016	A
450	4559	
500	5060	G

*Locked rotor current values are maximums.

9.5.1.3 Part-winding motors shall have a 50:50 winding ratio in order to have equal currents in both windings while running at nominal speed.

9.5.1.4* Motors Used with Variable Speed Controllers.

9.5.1.4.1 Motors used with variable speed controllers of NEMA MG-1, *Motors and Generators*, Part 30 or 31.

9.5.1.4.2 Motors shall be listed, suitable, and marked for inverter duty.

9.5.1.4.3 Listing shall not be required if 9.5.1.2 applies.

9.5.1.5 The corresponding values of locked rotor current for motors rated at other voltages shall be determined by multiplying the values shown by the ratio of 400 V to the rated voltage in Table 9.5.1.1(a).

9.5.1.6 Code letters of motors for all other voltages shall conform with those shown for 400 V in Table 9.5.1.1(a).

9.5.1.7 All motors shall be rated for continuous duty.

9.5.1.8 Electric motor-induced transients shall be coordinated with the provisions of 10.13.3 to prevent nuisance tripping of motor controller protective devices.

9.5.1.9 Motors for Vertical Shaft Turbine-Type Pumps.

9.5.1.9.1 Motors for vertical shaft turbine-type pumps shall be drip-proof, squirrel-cage induction type.

9.5.1.9.2 The motor shall be equipped with a nonreverse ratchet.

9.5.2 Current Limits.

9.5.2.1 The motor capacity in horsepower shall be such that the maximum motor current in any phase under any condition of pump load and voltage unbalance shall not exceed the motor-rated full-load current multiplied by the service factor.

9.5.2.2 The following shall apply to the service factor:

- (1) The maximum service factor at which a motor shall be used is 1.15.
- (2) Where the motor is used with a variable speed pressure limiting controller, the service factor shall not be used.

9.5.2.3 These service factors shall be in accordance with NEMA MG-1, *Motors and Generators*.

9.5.2.4 General-purpose (open and drip-proof) motors, totally enclosed fan-cooled (TEFC) motors, and totally enclosed nonventilated (TENV) motors shall not have a service factor larger than 1.15.

9.5.2.5 Motors used at altitudes above 3300 ft (1000 m) shall be operated or derated according to NEMA MG-1, *Motors and Generators*, Part 14.

9.5.3 Marking.

9.5.3.1 Marking of motor terminals shall be in accordance with NEMA MG-1, *Motors and Generators*, Part 2.

9.5.3.2 A motor terminal connecting diagram for multiple lead motors shall be furnished by the motor manufacturer.

9.6 On-Site Standby Generator Systems.

9.6.1 Capacity.

9.6.1.1 Where on-site generator systems are used to supply power to fire pump motors to meet the requirements of 9.3.2, they shall be of sufficient capacity to allow normal starting and running of the motor(s) driving the fire pump(s) while supplying all other simultaneously operated loads while meeting the requirements of Section 9.4.

9.6.1.2 A tap ahead of the on-site generator disconnecting means shall not be required.

9.6.2* Power Sources.

9.6.2.1 On-site standby generator systems shall comply with Section 9.4 and shall meet the requirements of Level 1, Type 10, Class X systems of NFPA 110.

9.6.2.2 The generator shall run and continue to produce rated nameplate power without shutdown or derate for alarms and warnings or failed engine sensors, except for overcurrent shutdown.

9.6.2.3 The generator fuel supply capacity shall be sufficient to provide 8 hours of fire pump operation at 100 percent of the rated pump capacity in addition to the supply required for other demands.

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9.6.3 Sequencing. Automatic sequencing of the fire pumps shall be permitted in accordance with 10.5.2.5.

9.6.4 Transfer of Power. Transfer of power to the fire pump controller between the normal supply and one alternate supply shall take place within the pump room.

9.6.5* Protective Devices.

9.6.5.1 Protective devices installed in the on-site power source circuits at the generator shall allow instantaneous pickup of the full pump room load and shall comply with NFPA 70, Section 700.28.

9.6.5.2 Circuit breakers shall have supervision by remote monitoring.

9.6.5.3 The fire pump circuit breaker shall not be required to be coordinated with the generator power source protective device, provided it is used in an individual branch circuit and is coordinated with all other line-side protective devices.

9.7 Junction Boxes. Where fire pump wiring to or from a fire pump controller is routed through a junction box, the following requirements shall be met:

- (1) The junction box shall be securely mounted.
- (2)* Mounting and installation of a junction box shall not violate the enclosure type rating of the fire pump controller(s).
- (3)* Mounting and installation of a junction box shall not violate the integrity of the fire pump controller(s) and shall not affect the short-circuit rating of the controller(s).
- (4) As a minimum, a Type 2, drip-proof enclosure (junction box) shall be used. The enclosure shall be listed to match the fire pump controller enclosure type rating.
- (5) Terminals, junction blocks, and splices, where used, shall be listed.
- (6) Neither a fire pump controller nor a fire pump power transfer switch, where provided, shall not be used as a junction box to supply other equipment, including a pressure maintenance (jockey) pump(s). (See 10.3.4.3.1 and 10.3.4.6.)
- (7) Neither a fire pump controller nor a fire pump power transfer switch shall be used as a junction box for wire splices.

9.8 Listed Electrical Circuit Protective System to Controller Wiring.

9.8.1* Where single conductors (individual conductors) are used, they shall be terminated in a separate junction box.

9.8.1.1 The junction box shall be installed ahead of the fire pump controller, a minimum of 12 in. (305 mm) beyond the fire-rated wall or floor bounding the fire zone.

9.8.1.2 Single conductors (individual conductors) shall not enter the fire pump enclosure separately.

9.8.2* Where required by the manufacturer of a listed electrical circuit protective system, by NFPA 70, or by the listing, the raceway between a junction box and the fire pump controller shall be sealed at the junction box end as required and in accordance with the instructions of the manufacturer. (See NFPA 70, Article 695.)

9.8.3 Standard wiring between the junction box and the controller shall be considered acceptable.

9.9 Raceway Terminations.

9.9.1 Listed conduit hubs shall be used to terminate raceway (conduit) to the fire pump controller.

9.9.2 The type rating of the conduit hub(s) shall be at least equal to that of the fire pump controller.

9.9.3 The installation instructions of the manufacturer of the fire pump controller shall be followed.

9.9.4 Alterations to the fire pump controller, other than conduit entry as allowed by NFPA 70 shall be approved by the authority having jurisdiction.

Chapter 10 Electric-Drive Controllers and Accessories

10.1 General.

10.1.1 Application.

10.1.1.1 This chapter covers the minimum performance and testing requirements for controllers and transfer switches for electric motors driving fire pumps.

10.1.1.2 Accessory devices, including fire pump alarm and signaling means are included where necessary to ensure the minimum performance of the equipment mentioned in 10.1.1.1.

10.1.2 Performance and Testing.

10.1.2.1 Listing. All controllers and transfer switches shall be specifically listed for electric motor-driven fire pump service.

10.1.2.2* Marking.

10.1.2.2.1 The controller and transfer switch shall be suitable for the available short-circuit current at the line terminals of the controller and transfer switch.

10.1.2.2.2 The controller and transfer switch shall be marked "Suitable for use on a circuit capable of delivering not more than _____ amperes RMS symmetrical at _____ volts ac," or "_____ amperes RMS symmetrical at _____ volts ac at short-circuit current rating," or equivalent, where the blank spaces shown shall have appropriate values filled in for each installation.

10.1.2.3 Freshpainting. All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

10.1.2.3.1 Controllers shipped in sections shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

10.1.2.3.2 Such controllers shall be reassembled in the field, and the proper assembly shall be verified by the manufacturer or designated representative.

10.1.2.4 Service Equipment Listing. All controllers and transfer switches shall be listed as "suitable for use as service equipment" where so used.

10.1.2.5 Additional Marking.

10.1.2.5.1 All controllers shall be marked "Electric Fire Pump Controller" and shall show plainly the name of the manufacturer, identifying designation, maximum operating pressure, enclosure type designation, and complete electrical rating.

10.1.2.5.2 Where multiple pumps serve different areas or portions of the facility, an appropriate sign shall be conspicuously attached to each controller indicating the area, zone, or portion of the system served by that pump or pump controller.

10.1.2.6 Service Arrangements. It shall be the responsibility of the pump manufacturer or its designated representative to make necessary arrangements for the services of a manufacturer's representative when needed for service and adjustment of the equipment during the installation, testing, and warranty periods.

10.1.2.7 State of Readiness. The controller shall be in a fully functional state within 10 seconds upon application of ac power.

10.1.3* Design. All electrical control equipment design shall comply with NFPA 70, Article 695, and other applicable documents.

10.2* Location.

10.2.1 Controllers shall be located as close as is practical to the motors they control and shall be within sight of the motors.

10.2.2 Controllers shall be located or protected so that they will not be damaged by water escaping from pumps or pump connections.

10.2.3 Current-carrying parts of controllers shall be not less than 12 in. (305 mm) above the floor level.

10.2.4 Working clearances around controllers shall comply with NFPA 70, Article 110.

10.3 Construction.

10.3.1 Equipment. All equipment shall be suitable for use in locations subject to a moderate degree of moisture, such as a damp basement.

10.3.2 Mounting. All equipment shall be mounted in a substantial manner on a single noncombustible supporting structure.

10.3.3 Enclosures.

10.3.3.1* The structure or panel shall be securely mounted in, as a minimum, a National Electrical Manufacturers Association (NEMA) Type 2, drip-proof enclosure(s) or an enclosure(s) with an ingress protection (IP) rating of IP31.

10.3.3.2 Where the equipment is located outside, or where special environments exist, suitably rated enclosures shall be used.

10.3.3.3 The enclosure(s) shall be grounded in accordance with NFPA 70, Article 250.

10.3.4 Connections and Wiring.

10.3.4.1 All busbars and connections shall be readily accessible for maintenance work after installation of the controller.

10.3.4.2 All busbars and connections shall be arranged so that disconnection of the external circuit conductors will not be required.

10.3.4.3 Means shall be provided on the exterior of the controller to read all line currents and all line voltages with an accuracy within 25 percent of motor nameplate voltage and current.

10.3.4.4 Continuous-Duty Basis.

10.3.4.4.1 Unless the requirements of 10.3.4.4.2 are met, busbars and other wiring elements of the controller shall be designed on a continuous-duty basis.

10.3.4.4.2 The requirements of 10.3.4.4.1 shall not apply to conductors that are in a circuit only during the motor starting period, which shall be permitted to be designed accordingly.

10.3.4.5 Field Connections.

10.3.4.5.1 A fire pump controller shall not be used as a junction box to supply other equipment.

10.3.4.5.2 No undervoltage, phase loss, frequency sensitive, or other device(s) shall be field installed that automatically or manually prohibits electrical activation of the motor controller.

10.3.4.5.3 Except as provided in 420.2.2(1) and 10.9.4, remote shutdown or interlock to prevent normal operation shall not be permitted unless approved by the authority having jurisdiction.

10.3.4.6 Electrical supply conductors for pressure maintenance (jockey or make-up) pump(s) shall not be connected to the fire pump controller.

10.3.5 Protection of Control Circuits.

10.3.5.1 Circuits that are necessary for proper operation of the controller shall not have overcurrent protective devices connected to them.

10.3.5.2 The secondary of the transformer and control circuitry shall be permitted to be ungrounded except as required in 10.6.5.4.

10.3.6* External Operation. All switching equipment for manual use in connecting or disconnecting or starting or stopping the motor shall be externally operable.

10.3.7 Electrical Diagrams and Instructions.

10.3.7.1 An electrical schematic diagram shall be provided and permanently attached to the inside of the controller enclosure.

10.3.7.2 All the field wiring terminals shall be plainly marked to correspond with the field connection diagram furnished.

10.3.7.3* Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

10.3.7.4 The installation instructions of the manufacturer of the fire pump controller shall be followed.

10.3.8 Marking.

10.3.8.1 Each motor control device and each switch and circuit breaker shall be marked to plainly indicate the name of the manufacturer, the designated identifying number, and the electrical rating in volts, horsepower, amperes, frequency, phases, and so forth, as appropriate.

10.3.8.2 The markings shall be so located as to be visible after installation.

10.4 Components.

10.4.1* Voltage Surge Arresters.

10.4.1.1 Unless the requirements of 10.4.1.3 or 10.4.1.4 are met, a voltage surge arrester complying with ANSI/IEEE C62.1, IEEE Standard for *Gas-Discharge Tubes: Surge Arresters for AC Power Circuits*, or ANSI/IEEE C62.11, IEEE Standard for *Mod. Gas-Discharge Arresters for Alternating Current Power Systems (1 to 4 kV)*, shall be installed from each phase to ground. (See 10.3.3.3.)

10.4.1.2 The surge arrester shall be rated to suppress voltage surges above line voltage.

10.4.1.3 The requirements of 10.4.1.1 and 10.4.1.2 shall not apply to controllers rated in excess of 600 V. (See Section 10.6.)

10.4.1.4 The requirements of 10.4.1.1 and 10.4.1.2 shall not apply where the controller can withstand without damage a 10 kV impulse in accordance with ANSI/IEEE C62.41, IEEE Recommended Practice for *Surge Voltages in Low-Voltage AC Power Circuits*, or where the controller is listed to withstand surges and impulses in accordance with ANSI/UL 1449, *Standard for Surge Protective Devices*.

10.4.2 Isolating Switch.

10.4.2.1 General.

10.4.2.1.1 The isolating switch shall be a manually operable motor circuit switch or a molded case switch having a horsepower rating equal to or greater than the motor horsepower.

10.4.2.1.2* A molded case switch having an ampere rating not less than 115 percent of the motor rated fullload current and also suitable for interrupting the motor locked rotor current shall be permitted.

10.4.2.1.3 A molded case isolating switch shall be permitted to have self-protecting instantaneous short-circuit overcurrent protection, provided that this switch does not trip unless the circuit breaker in the same controller trips.

10.4.2.2 Externally Operable. The isolating switch shall be externally operable.

10.4.2.3* Ampere Rating. The ampere rating of the isolating switch shall be at least 115 percent of the fullload current rating of the motor.

10.4.2.4 Warning.

10.4.2.4.1 Unless the requirements of 10.4.2.4.2 are met, the following warning shall appear on or immediately adjacent to the isolating switch:

WARNING

DO NOT OPEN OR CLOSE THIS SWITCH WHILE THE CIRCUIT BREAKER (DISCONNECTING MEANS) IS IN CLOSED POSITION.

10.4.2.4.2 Instruction Label. The requirements of 10.4.2.4.1 shall not apply where the requirements of 10.4.2.4.2.1 and 10.4.2.4.2.2 are met.

10.4.2.4.2.1 Where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither opened nor closed while the circuit breaker is closed, the warning label shall be permitted to be replaced with an instruction label that directs the order of operation.

10.4.2.4.2.2 This label shall be permitted to be part of the label required by 10.3.7.3.

10.4.2.5 Operating Handle.

10.4.2.5.1 Unless the requirements of 10.4.2.5.2 are met, the isolating switch operating handle shall be provided with a spring latch that shall be so arranged that it requires the use of the other hand to hold the latch released in order to permit opening or closing of the switch.

10.4.2.5.2 The requirements of 10.4.2.5.1 shall not apply where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither opened nor closed while the circuit breaker is closed.

10.4.3 Circuit Breaker (Disconnecting Means).

10.4.3.1* General. The motor branch circuit shall be protected by a circuit breaker that shall be connected directly to the load side of the isolating switch and shall have one pole for each ungrounded circuit conductor.

10.4.3.2 Mechanical Characteristics. The circuit breaker shall have the following mechanical characteristics:

- (1) It shall be externally operable. (See 10.3.6.)
- (2) It shall trip free of the handle.
- (3) A nameplate with the legend "Circuit breaker — disconnecting means" in letters not less than 1/8 in. (10 mm) high shall be located on the outside of the controller enclosure adjacent to the means for operating the circuit breaker.

10.4.3.3* Electrical Characteristics.

10.4.3.3.1 The circuit breaker shall have the following electrical characteristics:

- (1) A continuous current rating not less than 115 percent of the rated fullload current of the motor
- (2) Overcurrent-sensing elements of the thermal type
- (3) Instantaneous short-circuit overcurrent protection
- (4)* An adequate interrupting rating to provide the suitability rating of the controller discussed in 10.1.2.2
- (5) Capability of allowing normal and emergency starting and running of the motor without tripping (see 10.3.3.2)
- (6) An instantaneous trip setting of not more than 20 times the fullload current

10.4.3.3.1.1* The circuit breaker shall not trip when starting a motor from rest in the across-the-line (direct-on-line) mode, whether or not the controller is of the reduced inrush-starting type.

10.4.3.3.1.2* The circuit breaker shall not trip when power is interrupted from a running pump, or if the pump is restarted in less than 3 seconds after being shut down. If a control circuit preventing a re-start within 3 seconds is provided, this requirement shall not apply.

10.4.3.3.2* Current limiters, where integral parts of the circuit breaker, shall be permitted to be used to obtain the required interrupting rating, provided all the following requirements are met:

- (1) The breaker shall accept current limiters of only one rating.
- (2) The current limiters shall hold 3/50 percent of fullload motor current for a minimum of 30 minutes.

(3) The current limiters, where installed in the breaker, shall not open at locked rotor current.

(4) A spare set of current limiters of correct rating shall be kept readily available in a compartment or rack within the controller enclosure.

10.4.4 Locked Rotor Overcurrent Protection. The only other overcurrent protective device that shall be required and permitted between the isolating switch and the fire pump motor shall be located within the fire pump controller and shall possess the following characteristics:

- (1) For a direct-current or wound-rotor induction motor, the device shall be of the time-delay type having tripping times as follows:
 - (a) Between 8 seconds and 20 seconds at locked rotor current
 - (b) Three minutes at a minimum of 300 percent of motor fullload current
- (2) For a direct-current motor, the device shall be as follows:
 - (a) Of the instantaneous type
 - (b) Calibrated and set at a minimum of 400 percent of motor fullload current
- (3) There shall be visual means or markings clearly indicated on the device that proper settings have been made.
- (4)* It shall be possible to reset the device for operation immediately after tripping, with the tripping characteristics thereafter remaining unchanged.
- (5) Tripping shall be accomplished by opening the circuit breaker, which shall be of the external manual reset type.

10.4.5 Motor Starting Circuitry.

10.4.5.1 Motor Controller. The motor controller shall be horsepower rated and shall be of the magnetic type with a contact in each ungrounded conductor.

10.4.5.1.1 Running contactors shall be sized for both the locked rotor currents and the continuous running currents encountered.

10.4.5.1.2 Starting contactors shall be sized for both the locked rotor current and the acceleration (starting) encountered.

10.4.5.2 Timed Acceleration.

10.4.5.2.1 For electrical operation of reduced-voltage controllers, timed automatic acceleration of the motor shall be provided.

10.4.5.2.2 The period of motor acceleration shall not exceed 10 seconds.

10.4.5.3 Starting Resistors. Starting resistors shall be designed to permit one 5-second starting operation every 90 seconds for a period of not less than 1 hour.

10.4.5.4 Starting Reactors and Autotransformers.

10.4.5.4.1 Starting reactors and autotransformers shall comply with the requirements of ANSI/UL 508, *Standard for Industrial Control Equipment*, Table 92.1.

10.4.5.4.2 Starting reactors and autotransformers over 250 hp shall be permitted to be designed to Part 3 of ANSI/UL 508, *Standard for Industrial Control Equipment*, Table 92.1, in lieu of Part 4.

10.4.5.5 Soft Start Units.

10.4.5.5.1 Soft start units shall be horsepower rated or specifically designed for the service.

10.4.5.5.2 Bypass Contactor.

10.4.5.5.2.1 The bypass contactor shall comply with 10.4.5.1.

10.4.5.5.3 Soft start units shall comply with the duty cycle requirements in accordance with 10.4.5.4.1 and 10.4.5.4.2.

10.4.5.6 Operating Coils.

For controllers of 600 V or less, the operating coil(s) for any motor contactor(s) and any bypass contactor(s), if provided, shall be supplied directly from the main power voltage and not through a transformer.

10.4.5.7* Single-Phase Sensors in Controller.

10.4.5.7.1 Sensors shall be permitted to prevent a three-phase motor from starting under single-phase condition.

10.4.5.7.2 Such sensors shall not cause disconnection of the motor if it is running at the time of single-phase occurrence.

10.4.5.7.3 Such sensors shall be monitored to provide a local visible signal in the event of malfunction of the sensors.

10.4.5.8 No ground fault protection (tripping) shall be allowed.

10.4.5.9 A ground fault alarm shall be permitted.

10.4.6* Signal Devices on Controller.

10.4.6.1 Power Available Visible Indicator.

10.4.6.1.1 A visible indicator shall monitor the availability of power in all phases at the line terminals of the motor contactor or of the bypass contactor, if provided.

10.4.6.1.2 If the visible indicator is a pilot lamp, it shall be accessible for replacement.

10.4.6.1.3 When power is supplied from multiple power sources, monitoring of each power source for phase reversal shall be permitted at any point electrically upstream of the line terminals of the contactor, provided all sources are monitored.

10.4.6.2 Phase Reversal.

10.4.6.2.1 Phase reversal of the power source to which the line terminals of the motor controller are connected shall be indicated by a visible indicator.

10.4.6.2.2 When power is supplied from multiple power sources, monitoring of each power source for phase reversal shall be permitted at any point electrically upstream of the line terminals of the contactor, provided all sources are monitored.

10.4.7* Fire Pump Alarm and Signal Devices Remote from Controller.

10.4.7.1 Where the pump room is not constantly attended, audible or visible signals powered by a source not exceeding 125 V shall be provided at a point of constant attendance.

10.4.7.2 These fire pump alarms and signals shall indicate the information in 10.4.7.2.1 through 10.4.7.2.4.

10.4.7.2.1 Pump or Motor Running. The signal shall activate whenever the controller has operated into a motor-running condition.

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10.4.7.2.1.1 This signal circuit shall be energized by a separate reliable supervised power source or from the pump motor power, reduced to not more than 125 V.

10.4.7.2.2 Loss of Phase.

10.4.7.2.2.1 The fire pump alarm shall activate whenever any phase at the line terminals of the motor contactor is lost.

10.4.7.2.2.2 All phases shall be monitored. Such monitoring shall detect loss of phase whether the motor is running or at rest.

10.4.7.2.2.3 When power is supplied from multiple power sources, monitoring of each power source for phase loss shall be permitted at any point electrically upstream of the line terminals of the contactor, provided all sources are monitored.

10.4.7.2.3 Phase Reversal. This fire pump alarm circuit shall be energized by a separate reliable supervised power source or from the pump motor power, reduced to not more than 125 V. (See 10.4.6.2.)

10.4.7.2.3.1 The fire pump alarm shall activate whenever the three-phase power at the line terminals of the motor contactor is reversed.

10.4.7.2.4 Controller Connected to Alternate Source.

10.4.7.2.4.1 Where two sources of power are supplied to meet the requirements of 10.5.2, this signal shall indicate whenever the alternate source is the source supplying power to the controller.

10.4.7.2.4.2 This signal circuit shall be energized by a separate, reliable, supervised power source, reduced to not more than 125 V.

10.4.8 Controller Controls for Remote Indication. Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions in 10.4.7.2.1 through 10.4.7.2.3 and when a controller is equipped with a transfer switch in accordance with 10.4.7.2.4.

10.5 Starting and Control.

10.5.1* Automatic and Nonautomatic.

10.5.1.1 An automatic controller shall be self-acting to start, run, and protect a motor.

10.5.1.2 An automatic controller shall be arranged to start the driver upon actuation of a pressure switch or nonpressure switch actuated in accordance with 10.5.2.1 or 10.5.2.2.

10.5.1.3 An automatic controller shall be operable also as a nonautomatic controller.

10.5.1.4 A nonautomatic controller shall be actuated by manually initiated electrical means and by manually initiated mechanical means.

10.5.2 Automatic Controller.

10.5.2.1* Water Pressure Control.

10.5.2.1.1 Pressure-Actuated Switches.

10.5.2.1.1.1 A pressure-actuated switch or electronic pressure sensor having adjustable high- and low-calibrated setpoints shall be provided as part of the controller.

10.5.2.1.1.2 For multistage multipump pumps, a dedicated pressure-actuated switch or electronic pressure sensor as described in 10.5.2.1.1.1 shall be provided for each discharge port of the pump as part of the controller.

10.5.2.1.1.3 For multistage multipump pumps, a dedicated pressure recorder as described in 10.5.2.1.1.2 shall be provided for each discharge port of the pump as part of the controller.

10.5.2.1.1.4 The requirements of 10.5.2.1.1.1 and 10.5.2.1.1.2 shall not apply in a nonpressure-actuated controller, where the pressure-actuated switch shall not be required.

10.5.2.1.2 There shall be no pressure switches or restrictive orifice employed within the pressure switch or pressure responsive means.

10.5.2.1.3* Where an electronic pressure sensor is used to automatically control fire pump operation, the fire pump controller shall monitor the transducer during automatic testing.

10.5.2.1.3.1* Where the transducer pressure reading exceeds 10 psi (0.68 bar) during any automatic pump start that was initiated by the solenoid drain valve, as required by 10.5.2.7.3, the controller shall activate a visual and audible alarm that can be silenced.

10.5.2.1.3.2* Where an electronic pressure sensor is used to control fire pump operation, the fire pump controller shall monitor for and provide a signal for the following electronic pressure sensor conditions:

- (1) Any time the transducer output is less than 10 percent of rated span or below its rated zero pressure output
- (2) Any time the pressure transducer reading is more than 10 percent above its rated full-scale output

10.5.2.1.4 There shall be no valve or other restrictions within the controller ahead of the pressure switch or pressure responsive means.

10.5.2.1.5 This switch shall be responsive to water pressure in the fire protection system.

10.5.2.1.6 The pressure sensing element of the switch shall be capable of withstanding a momentary water pressure of 600 psi (27.6 bar) or 153 percent of fire pump controller rated operating pressure, whichever is higher, without losing its accuracy.

10.5.2.1.7 Suitable provision shall be made for relieving pressure in the pressure-actuated switch to allow testing of the operation of the controller and the pumping unit. (See Figure A.3.1(b) and Figure A.3.3(b).)

10.5.2.1.8 Water pressure control shall be in accordance with 10.5.2.1.1 through 10.5.2.1.6.

10.5.2.1.8.1 Pressure switch actuation at the low adjustment setting shall initiate pump starting sequence (if pump is not already in operation).

10.5.2.1.8.2* A pressure recording device shall record the pressure in each fire pump controller upstreaming line at the input to the controller.

10.5.2.1.8.3 The pressure recorder shall be listed as part of the controller or shall be a separately listed unit installed to sense the pressure at the input of the controller.

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10.5.2.1.8.4 The recorder shall be capable of operating for at least 72 days without being reset or resound.

10.5.2.1.8.5 The pressure sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least 160 psi (27.6 bar) or 133 percent of fire pump controller rated operating pressure, whichever is greater, without losing its accuracy.

10.5.2.1.8.6 For variable speed pressure limiting control, a 1/2 in. (12.7 mm) nominal size inside diameter pressure line shall be connected to the discharge piping at a point recommended by the variable speed control manufacturer. The connection shall be between the discharge check valve and the discharge control valve.

10.5.2.1.8.7 Access to the recorder data shall not require opening the controller, nor require taking the controller out of service.

10.5.2.2 Nonpressure Switch-Actuated Automatic Controller.

10.5.2.2.1 Nonpressure switch-actuated automatic fire pump controllers shall commence the controller's starting sequence by the automatic opening of a remote contact(s).

10.5.2.2.2 The pressure switch shall not be required.

10.5.2.2.3 There shall be no means capable of stopping the fire pump motor except those on the fire pump controller.

10.5.2.3 Fire Protection Equipment Control.

10.5.2.3.1 Where the pump supplies special water control equipment (deluge valves, dry pipe valves, etc.), it shall be permitted to start the motor before the pressure-actuated switch(es) would do so.

10.5.2.3.2 Under such conditions the controller shall be equipped to start the motor upon operation of the fire protection equipment.

10.5.2.3.3 Starting of the motor shall be initiated by the opening of the control circuit loop containing this fire protection equipment.

10.5.2.4 Manual Electric Control at Remote Station. Where additional control stations for causing unautomatic continuous operation of the pumping unit, independent of the pressure-actuated switch, are provided at locations remote from the controller, such stations shall not be operable to stop the motor.

10.5.2.5 Sequence Starting of Pumps.

10.5.2.5.1 The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one driver from starting simultaneously with any other driver.

10.5.2.5.2 Each pump supplying suction pressure to another pump shall be arranged to start within 10 seconds before the pump it supplies.

10.5.2.5.2.1 Starting of the motor shall be initiated by the opening of the control circuit loop containing this fire protection equipment.

10.5.2.5.3 If water requirements call for more than one pumping unit to operate, the units shall start at intervals of 5 to 10 seconds.

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10.5.2.5.4 Failure of a leading driver to start shall not prevent subsequent pumping units from starting.

10.5.2.6 External Circuits Connected to Controllers.

10.5.2.6.1 External control circuits that extend outside the fire pump room shall be arranged so that failure of any external circuit (open, ground fault, or short circuit) shall not prevent operation of pump(s) from other internal or external means.

10.5.2.6.2 Breakage, disconnection, shorting of the wires, ground fault, or loss of power to these circuits shall be permitted to cause continuous running of the fire pump but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits.

10.5.2.6.3 All control conductors within the fire pump room that are not fault tolerant as described in 10.5.2.6.1 and 10.5.2.6.2 shall be protected against mechanical injury.

10.5.2.7 Automatic Testing.

10.5.2.7.1 The controller equipment shall be arranged to automatically start, run, and shut down the motor at the minimum no-flow test frequency and duration required by NFPA 25.

10.5.2.7.2 Performance of the automatic testing shall be recorded as a pressure drop indication on the pressure recorder.

10.5.2.7.3 A solenoid valve drain on the pressure control line shall be the initiating means.

10.5.2.7.4 In a non-pressure-actuated controller, the automatic testing shall be permitted to be initiated by a means other than a solenoid valve.

10.5.2.7.5 A visible indicator and audible alarm shall be provided when the controller fails to start from the automatic mode.

10.5.3 Nonautomatic Controller.

10.5.3.1 Manual Electric Control at Controller.

10.5.3.1.1 There shall be a manually operated switch on the control panel so arranged that, when the motor is started manually, its operation cannot be affected by the pressure-actuated switch.

10.5.3.1.2 The arrangement shall also provide that the unit will remain in operation until manually shut down.

10.5.3.2* Emergency-Run Mechanical Control at Controller.

10.5.3.2.1 The controller shall be equipped with an emergency-run handle or lever that operates to mechanically close the motor-circuit switching mechanism.

10.5.3.2.1.1 This handle or lever shall provide for nonautomatic continuous running operation of the motor(s), independent of any electric control circuits, magnets, or equivalent devices and independent of the pressure-actuated control switch.

10.5.3.2.1.2 Means shall be incorporated for mechanically latching or holding the handle or lever for manual operation in the actuated position.

10.5.3.2.1.3 The mechanical latching shall be designed to be automatic or manual.

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10.5.3.2.2 The handle or lever shall be arranged to move in one direction only from the off position to the final position.

10.5.3.2.3 The motor starter shall return automatically to the off position in case the operator releases the starter handle or lever in any position but the full running position.

10.5.3.2.4 The operating handle shall be marked or labeled as to function and operation.

10.5.3.3 Manual Testing of Automatic Operation.

10.5.3.3.1 The controller shall be arranged to manually start the motor by opening the solenoid valve drain when so initiated by the operator.

10.5.3.3.2 For a non-pressure-actuated controller, the manual test shall be permitted to be initiated by a means other than a solenoid valve.

10.5.4 Methods of Stopping. Shutdown shall be accomplished by the methods in 10.5.4.1 and 10.5.4.2.

10.5.4.1 Manual. Manual shutdown shall be accomplished by operation of a pushbutton on the outside of the controller enclosure that, in the case of automatic controllers, shall return the controller to the full automatic position.

10.5.4.2 Automatic Shutdown After Automatic Start. Automatic shutdown shall not be permitted if starting and running causes are present.

10.5.4.2.1 Automatic shutdown shall be permitted only in the following circumstances:

- (1)* During automatic testing in accordance with 10.5.2.7
- (2) Where approved by the authority having jurisdiction

10.5.4.2.2 Where automatic shutdown after automatic start is permitted, a minimum run timer set for at least 10 minutes shall be used.

10.6 Controllers Rated in Excess of 600 V.

10.6.1 Control Equipment. Controllers rated in excess of 600 V shall comply with the requirements of Chapter 10, except as provided in 10.6.2 through 10.6.8.

10.6.2 Provisions for Testing.

10.6.2.1 The provisions of 10.6.3 shall not apply.

10.6.2.2 An ammeter(s) shall be provided on the controller with a suitable means for reading the current in each phase.

10.6.2.3 An indicating voltmeter(s), deriving power of not more than 125 V from a transformer(s) connected to the high-voltage supply, shall also be provided with a suitable means for reading each phase voltage.

10.6.3 Disconnecting Under Load.

10.6.3.1 Provisions shall be made to prevent the isolating switch from being opened under load.

10.6.3.2 A loadbreak disconnecting means shall be permitted to be used in lieu of the isolating switch if the fault clearing and interrupting ratings equal or exceed the requirements of the installation.

10.6.4 Pressure-Actuated Switch Location. Special precautions shall be taken in locating the pressure-actuated switch

called for in 10.5.2.1 to prevent any water leakage from coming in contact with high-voltage components.

10.6.5 Low-Voltage Control Circuit.

10.6.5.1 The low-voltage control circuit shall be supplied from the high-voltage source through a stepdown transformer(s) protected by high-voltage fuses in each primary line.

10.6.5.2 The transformer power supply shall be interrupted when the isolating switch is in the open position.

10.6.5.3 The secondary of the transformer and control circuitry shall otherwise comply with 10.3.5.

10.6.5.4 One secondary line of the high-voltage transformer or transformers shall be grounded unless all control and operator devices are rated for use at the high (primary) voltage.

10.6.5.5 Current Transformers. Unless rated at the incoming line voltage, the secondaries of all current transformers used in the high-voltage path shall be grounded.

10.6.6 Indicators on Controller.

10.6.6.1 Specifications for controllers rated in excess of 600 V shall differ from those in 10.4.8.

10.6.6.2 A visible indicator shall be provided to indicate that power is available.

10.6.6.3 The current supply for the visible indicator shall come from the secondary of the control circuit transformer through resistors, if found necessary, or from a small-capacity stepdown transformer, which shall reduce the control transformer secondary voltage to that required for the visible indicator.

10.6.6.4 If the visible indicator is a pilot lamp, it shall be accessible for replacement.

10.6.7 Protection of Personnel from High Voltage. Necessary provisions shall be made, including such interlocks as might be needed, to protect personnel from accidental contact with high voltage.

10.6.8 Disconnecting Means. A contactor in combination with current-limiting motor circuit fuses shall be permitted to be used in lieu of the circuit breaker (disconnecting means) required in 10.4.3.1 if all of the following requirements are met:

- (1) Current-limiting motor circuit fuses shall be mounted in the enclosure between the isolating switch and the contactor and shall interrupt the short-circuit current available at the controller input terminals.
- (2) These fuses shall have an adequate interrupting rating to provide the suitability rating (see 10.1.2.2) of the controller.
- (3) The current-limiting fuses shall be sized to hold 600 percent of the full-load current rating of the motor for at least 100 seconds.
- (4) A spare set of fuses of the current rating shall be kept readily available in a compartment or rack within the controller enclosure.

10.6.9 Locked Rotor Overcurrent Protection.

10.6.9.1 Tripping of the locked rotor overcurrent device required by 10.4.4 shall be permitted to be accomplished by

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opening the motor contactor coil circuit(s) to drop out the contactor.

10.6.9.2 Means shall be provided to restore the controller to normal operation by an external manually reset device.

10.6.10 Emergency-Run Mechanical Control at Controller.

10.6.10.1 The controller shall comply with 10.5.3.2.1 and 10.5.3.2.2, except that the mechanical latching can be automatic.

10.6.10.2 Where the controller is latched in, the locked rotor overcurrent protection of 10.4.4 shall not be required.

10.7 Limited-Service Controllers.

10.7.1 Limitations. Limited service controllers consisting of automatic controllers for across-the-line starting of squirrel-cage motors of 30 hp or less, 600 V or less, shall be permitted to be installed where such use is acceptable to the authority having jurisdiction.

10.7.2 Requirements. The provisions of Sections 10.1 through 10.5 shall apply, unless specifically addressed in 10.8.2.1 through 10.8.2.3.

10.7.2.1 In lieu of 10.1.2.5.1, such controller shall be marked "Limited-Service Controller" and shall show plainly the name of the manufacturer, the identifying designation, the maximum operating pressure, the enclosure type designation, and the complete electrical rating.

10.7.2.2 The controller shall have a short-circuit current rating not less than 10,000 A.

10.7.2.3 The manually operated isolating switch specified in 10.4.2 shall not be required.

10.8* Power Transfer for Alternate Power Supply.

10.8.1 General.

10.8.1.1 Where required by the authority having jurisdiction or to meet the requirements of 9.3.2 where an on-site electrical power transfer device is used for power source selection, such switch shall comply with the provisions of Section 10.8 as well as Sections 10.1, 10.2, and 10.3 and 10.4.1.

10.8.1.2 Manual transfer switches shall not be used to transfer power between the normal supply and the alternate supply to the fire pump controller.

10.8.1.3 No remote device(s) shall be installed that will prevent automatic operation of the transfer switch.

10.8.2* Fire Pump Controller and Transfer Switch Arrangements.

10.8.2.1 Arrangement I (Listed Combination Fire Pump Controller and Power Transfer Switch).

10.8.2.1.1 Self-Contained Power Switching Assembly. Where the power transfer switch consists of a self-contained power switching assembly, such assembly shall be housed in a fire-rated compartment of the fire pump controller or in a separate enclosure attached to the controller and marked "Fire Pump Power Transfer Switch."

10.8.2.1.2 Isolating Switch.

10.8.2.1.2.1 An isolating switch, complying with 10.4.2, located within the power transfer switch enclosure or compartment

shall be provided ahead of the alternate input terminals of the transfer switch.

10.8.2.1.2.2 The isolating switch shall be suitable for the available short circuit of the alternate source.

10.8.2.1.3 Circuit Breaker. The transfer switch emergency side shall be provided with a circuit breaker complying with 10.1.3 and 10.1.4.

10.8.2.1.4 Cautionary Marking. The fire pump controller and transfer switch (see 10.8.2.1) shall each have a cautionary marking to indicate that the isolating switch for both the controller and the transfer switch is opened before servicing the controller, transfer switch, or motor.

10.8.2.1.5 Turning off the normal source isolating switch on the normal source circuit breaker shall not inhibit the transfer switch from operating as required by 10.8.3.6.1 through 10.8.3.6.4.

10.8.2.2 Arrangement II (Individually Listed Fire Pump Controller and Power Transfer Switch). The following shall be provided:

- (1) A fire pump controller power transfer switch complying with Sections 9.6 and 10.8 and a fire pump controller shall be provided. The overcurrent protection required by 10.8.2.2(2) and the isolating switch required by 10.8.2.2(3) shall be permitted to be provided in a separate enclosure upstream of the transfer switch.
- (2) The transfer switch overcurrent protection for both the normal and alternate sources shall comply with 9.2.3.4 or 9.2.3.4.1.
- (3) An instantaneous trip circuit breaker shall be permitted in lieu of the overcurrent devices specified in 10.8.2.2(2) provided it is part of a transfer switch assembly listed for fire pump service and complies with 9.2.3.4.1.
- (4) An isolating switch ahead of the alternate source input terminals of the transfer switch shall meet the following requirements:
 - (a) The isolating switch shall be externally operable and lockable in both the closed and the open position.
 - (b) A placard shall be externally installed on the isolating switch stating "Fire Pump Isolating Switch," with letters at least 1 in. (25 mm) in height.
 - (c) A placard shall be placed adjacent to the fire pump controller stating the location of the isolating switch and the location of the key (if the isolating switch is locked).
 - (d) The isolating switch shall be supervised by one of the following methods to indicate when it is not closed:
 - i. Central station, proprietary, or remote station signal service.
 - ii. Local signaling device that will cause the sounding of an audible signal at a constantly attended point.
 - iii. Locking the isolating switch closed.
 - iv. Sealing of isolating switches and approved weekly tested inspection where isolating switches are located within fenced enclosures or in buildings under the control of the owner.

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- (e) This supervision shall operate an audible and visible signal on the transfer switch and permit monitoring at a remote point, where required.
- (5) The isolation switch shall not have short circuit or overcurrent protection as part of the switching mechanism of the isolating switch.
- (6) The transfer switch shall be the delayed transition type with a maximum delay time of 3 seconds.

10.8.2.3 Transfer Switch. Each fire pump shall have its own dedicated transfer switch(es) where a transfer switch(es) is required.

10.8.3 Power Transfer Switch Requirements.

10.8.3.1 Listing. The power transfer switch shall be specifically listed for fire pump service.

10.8.3.2 Suitability. The power transfer switch shall be suitable for the available short-circuit currents at the transfer switch normal and alternate input terminals.

10.8.3.3 Electrically Operated and Mechanically Held. The power transfer switch shall be electrically operated and mechanically held.

10.8.3.4 Horsepower or Ampere Rating.

10.8.3.4.1 Where rated in horsepower, the power transfer switch shall have a horsepower rating at least equal to the motor horsepower.

10.8.3.4.2 Where rated in amperes, the power transfer switch shall have an ampere rating not less than 115 percent of the motor fullload current and also be suitable for switching the motor locked rotor current.

10.8.3.5 Manual Means of Operation.

10.8.3.5.1 A means for safe manual (non-electrical) operation of the power transfer switch shall be provided.

10.8.3.5.2 This manual means shall not be required to be externally operable.

10.8.3.6 Undervoltage and Phase-Sensing Devices.

10.8.3.6.1 The power transfer switch shall be provided with undervoltage-sensing devices to monitor all ungrounded lines of the normal power source.

10.8.3.6.2 Where the voltage on any phase of the normal source falls below 85 percent of nominal voltage, the power transfer switch shall automatically initiate starting of the standby generator, if provided and not running, and initiate transfer to the alternate source.

10.8.3.6.3 Where the voltage on all phases of the normal source returns to within acceptable limits, the fire pump controller shall be permitted to be retransferred to the normal source.

10.8.3.6.4 Phase reversal of the normal source power (see 10.4.6.2) shall cause a simulated normal source power failure upon sensing power reversal.

10.8.3.6.5 For Arrangement II Units, the sensing of voltage described in 10.8.3.6.2 shall be permitted at the input to the power transfer switch instead of at the load terminals of the fire pump controller circuit breaker.

10.8.3.7 Voltage- and Frequency-Sensing Devices. Unless the requirements of 10.8.3.7.5 are met, the requirements of 10.8.3.7.1 and 10.8.3.7.2 shall apply.

10.8.3.7.1 Voltage- and frequency-sensing devices shall be provided to monitor at least one ungrounded conductor of the alternate power source.

10.8.3.7.2 Transfer to the alternate source shall be inhibited until there is adequate voltage and frequency to serve the fire pump load.

10.8.3.7.3 Where the fire pump controller is marked to indicate that the alternate source is provided by a second utility power source, the requirements of 10.8.3.7.1 and 10.8.3.7.2 shall not apply, and undervoltage-sensing devices shall monitor all ungrounded conductors in lieu of a frequency-sensing device.

10.8.3.7.4 Visible Indicators. Two visible indicators shall be provided to externally indicate the power source to which the fire pump controller is connected.

10.8.3.9 Retransfer.

10.8.3.9.1 Means shall be provided to delay retransfer from the alternate power source to the normal source until the normal source is stabilized.

10.8.3.9.2 This time delay shall be automatically bypassed if the alternate source fails.

10.8.3.10 In-Rush Currents. Means shall be provided to prevent higher than normal in-rush currents when transferring the fire pump motor from one source to the other.

10.8.3.10.1 The use of an "in-phase monitor" to comply with the requirements of 10.8.3.10 shall be prohibited.

10.8.3.10.2 The use of an intentional delay via an open neutral position of the transfer switch to comply with the requirements of 10.8.3.10 shall be prohibited for Arrangement I.

10.8.3.10.3 The use of an intentional delay via an open neutral position of the transfer switch to comply with the requirements of 10.8.3.10 shall be permitted for Arrangement II.

10.8.3.11* Overcurrent Protection. The power transfer switch shall not have short circuit or overcurrent protection as part of the switching mechanism of the transfer switch.

10.8.3.12 Additional Requirements. The following shall be provided:

- (1) A device to delay starting of the alternate source generator to prevent nuisance starting in the event of momentary dips and interruptions of the normal source
- (2) A circuit lock to the alternate source generator whereby either the opening or closing of the circuit will start the alternate source generator (when commanded by the power transfer switch) (see 10.8.3.6)
- (3) A means to prevent sending of the signal for starting of the alternate source generator when commanded by the power transfer switch, if the alternate isolating switch or the alternate circuit breaker is in the open or tripped position

10.8.3.12.1 The alternate isolating switch and the alternate circuit breaker shall be monitored to indicate when one of

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them is in the open or tripped position, as specified in 10.8.3.12.3).

10.8.3.12.2 Supervision shall operate an audible and visible signal on the fire pump controller/automatic transfer switch combination and permit monitoring at a remote point where required.

10.8.3.13 Momentary Test Switch. A momentary test switch, externally operable, shall be provided on the enclosure that will simulate a normal power source failure.

10.8.3.14 Remote Indication. Auxiliary open or closed contacts mechanically operated by the fire pump power transfer switch mechanism shall be provided for remote indication in accordance with 10.4.8.

10.9 Controllers for Additive Pump Motors.

10.9.1 Control Equipment. Controllers for additive pump motors shall comply with the requirements of Sections 10.1 through 10.5 (and Section 10.8, where required) unless specifically addressed in 10.9.2 through 10.9.5.

10.9.2 Automatic Starting. In lieu of the pressure-actuated switch described in 10.5.2.1, automatic starting shall be capable of being accomplished by the automatic operating of a closed circuit lock containing this fire protection equipment.

10.9.3 Methods of Stopping.

10.9.3.1 Manual shutdown shall be provided.

10.9.3.2 Automatic shutdown shall not be permitted.

10.9.4 Lockout.

10.9.4.1 Where required, the controller shall contain a lock-out feature where used in a duty-standby application.

10.9.4.2 Where supplied, this lockout shall be indicated by a visible indicator and provisions for annunciating the condition at a remote location.

10.9.5 Marking. The controller shall be marked "Additive Pump Controller."

10.10* Controllers with Variable Speed Pressure Limiting Control or Variable Speed Suction Limiting Control.

10.10.1 Control Equipment.

10.10.1.1 Controllers equipped with variable speed pressure limiting control or variable speed suction limiting control shall comply with the requirements of Chapter 10, except as provided in 10.10.1.1 through 10.10.1.11.

10.10.1.2 Controllers with variable speed pressure limiting control or variable speed suction limiting control shall be listed for fire service.

10.10.1.3 The variable speed pressure limiting control or variable speed suction limiting control shall have a horsepower rating at least equal to the motor horsepower or, where rated in amperes, shall have an ampere rating not less than the motor fullload current.

10.10.1.4 Controllers for motors driving constant torque loads, such as positive displacement water mist or additive (foam) pumps shall be rated for constant torque applications, and the variable frequency drive (VFD) unit in such controllers shall be rated for constant torque motor load.

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10.10.2 Additional Marking. In addition to the markings required in 10.10.2.1, the controller shall be marked with the maximum ambient temperature rating.

10.10.3* Bypass Operation.

10.10.3.1* Upon failure of the variable speed pressure limiting control to keep the system pressure at or above the set pressure of the variable speed pressure limiting control system, the controller shall bypass and isolate the variable speed pressure limiting control system and operate the pump at rated speed.

10.10.3.1.1 Low Pressure. If the system pressure remains below the set pressure for more than 15 seconds, the bypass operation shall occur.

10.10.3.1.2* Drive Not Operational. If the variable speed drive indicates that it is not operational within 5 seconds, the bypass operation shall occur.

10.10.3.1.3* Means shall be provided to prevent higher than normal in-rush currents when transferring the fire pump motor from the variable speed mode to the bypass mode.

10.10.3.2 When the variable speed pressure limiting control is bypassed, the unit shall remain bypassed until manually restored.

10.10.3.3 The bypass controllers shall be operable using the emergency-run handle or lever defined in 10.5.3.2.

10.10.3.4 Automatic Shutdown. When the variable speed pressure limiting control is bypassed, automatic shutdown of the controller shall be as permitted by 10.5.1.2.

10.10.3.5 When the manual selection means required in 10.10.3.1 is used to initiate a switchover from variable speed to bypass mode, if the pump is running in the variable speed mode and one of the conditions in 10.10.3 that require the controller to initiate the bypass operation exist, the controller shall be arranged to provide a restart delay to allow the motor to be de-energized before it is reenergized in the bypass mode.

10.10.4 Isolation.

10.10.4.1 The variable speed drive shall be line and load isolated when not in operation.

10.10.4.2 The variable speed drive load isolation contactor and the bypass contactor shall be mechanically and electrically interlocked to prevent simultaneous closure.

10.10.5* Circuit Protection.

10.10.5.1 Separate variable speed drive circuit protection shall be provided between the line side of the variable speed drive and the load side of the circuit breaker required in 10.1.3.

10.10.5.2 The circuit protection required in 10.10.5.1 shall be coordinated such that the circuit breaker in 10.1.3 does not trip due to a fault condition in the variable speed circuitry.

10.10.6 Power Quality.

10.10.6.1 Power quality correction equipment shall be located in the variable speed circuit.

10.10.6.1.1 As a minimum, 5 percent line reactance shall be provided.

10.10.6.2* Where higher system voltages or longer cable lengths exist, the cable length and motor requirements shall be coordinated.

10.10.6.3 Coordination shall not be required where the system voltage does not exceed 480 V and cable lengths between the motor and controller do not exceed 100 ft (30.5 m) (see 10.10.6.2).

10.10.7 Local Control.

10.10.7.1 All control devices required to keep the controller in automatic operation shall be within lockable enclosures.

10.10.7.2 Except as provided in 10.10.7.2.1, the variable speed pressure sensing element connected in accordance with 10.5.2.1.8.6 shall only be used to control the variable speed drive.

10.10.7.2.1 Where redundant pressure sensing elements are provided as part of a water mist positive displacement pumping unit, they shall be permitted for other system functions.

10.10.7.3 Means shall be provided to manually select between variable speed and bypass mode.

10.10.7.4 Except as provided in 10.10.7.4.2, common pressure control shall not be used for multiple pump installations.

10.10.7.4.1 Each controller pressure sensing control circuit shall operate independently.

10.10.7.4.2 A common pressure control shall be permitted to be used for a water mist positive displacement pumping unit controller.

10.10.8 Indicating Devices on Controller.

10.10.8.1 Drive Failure. A visible indicator shall be provided to indicate when the variable speed drive has failed.

10.10.8.2 Bypass Mode. A visible indicator shall be provided to indicate when the controller is in bypass mode.

10.10.8.3 Variable Speed Pressure Limiting Control Overpressure. Visible indication shall be provided on all controllers equipped with variable speed pressure limiting control to actuate at 115 percent of set pressure.

10.10.9 Controller Contacts for Remote Indication. Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions in 10.10.8.

10.10.10 System Performance.

10.10.10.1* The controller shall be provided with suitable adjusting means to account for various field conditions.

10.10.10.2 Operation at reduced speed shall not result in motor overheating.

10.10.10.3 The maximum operating frequency shall not exceed line frequency.

10.10.10.4 Within 20 seconds after a demand to start, pumps shall supply and maintain a stable discharge pressure (± 10 percent) throughout the entire range of operation.

10.10.10.4.1 The discharge pressure shall be permitted to restabilize whenever the flow condition changes.

10.10.11 Critical Settings. Means shall be provided and permanently attached to the inside of the controller enclosure to record the following settings:

- (1) Variable speed pressure limiting set point setting
- (2) Pump start pressure
- (3) Pump stop pressure

10.10.12 Variable Speed Drives for Vertical Pumps.

10.10.12.1 The pump supplier shall inform the controller manufacturer of any and all critical resonant speeds within the operating speed range of the pump, which is from zero speed up to full speed.

10.10.12.1.1 The controller shall avoid operating at or ramping through these speeds.

10.10.12.1.2 The controller shall make use of skip frequencies with sufficient bandwidth to avoid exciting the pump into resonance.

10.10.12.2 When water-lubricated pumps with line shaft bearings are installed, the pump manufacturer shall inform the controller manufacturer of the maximum allowed time for water to reach the top bearing under the condition of the lowest anticipated water level of the well or reservoir.

10.10.12.2.1 The controller shall provide a ramp up speed within this time period.

10.10.12.3 The ramp down time shall be approved or agreed to by the pump manufacturer.

10.10.12.4 Any skip frequencies employed and their bandwidth shall be included along with the information required in 10.10.11.

10.10.12.5 Ramp up and ramp down times for water-lubricated pumps shall be included along with the information required in 10.10.11.

Chapter 11 Diesel Engine Drive

11.1 General.

11.1.1 This chapter provides requirements for minimum performance of diesel engine drives.

11.1.2 Accessory devices, such as monitoring and signaling means, are included where necessary to ensure minimum performance of the aforementioned equipment.

11.1.3* Engine Type.

11.1.3.1 Diesel engines for fire pump drive shall be of the compression ignition type.

11.1.3.2 Spark-ignited internal combustion engines shall not be used.

11.2 Engines.

11.2.1 Listing. Engines shall be listed for fire pump service.

11.2.2 Engine Ratings.

11.2.2.1 Engines shall have a nameplate indicating the listed horsepower rating available to drive the pump.

11.2.2.2* The horsepower capability of the engine, when equipped for fire pump service, shall have a 4-hour minimum

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horsepower rating not less than 10 percent greater than the listed horsepower on the engine nameplate.

11.2.2.3 Engines shall be acceptable for horsepower ratings listed by the testing laboratory for standard SAE conditions.

11.2.2.4* A deduction of 3 percent from engine horsepower rating at standard SAE conditions shall be made for each 100 ft (30 m) of altitude above 300 ft (91 m).

11.2.2.5* A deduction of 1 percent from engine horsepower rating as corrected to standard SAE conditions shall be made for every 10°F (5.6°C) above 77°F (25°C) ambient temperature.

11.2.2.6 Where right-angle gear drives (see 7.5.1.8) are used between the vertical turbine pump and its drive, the horsepower requirement of the pump shall be increased to allow for power loss in the gear drive.

11.2.2.7 After the requirements of 11.2.2.1 through 11.2.2.6 have been complied with, engines shall have a 4-hour minimum horsepower rating equal to or greater than the brake horsepower required to drive the pump at its rated speed under any conditions listed for environmental conditions under pump load.

11.2.3 Engine Power Connection to Pump.

11.2.3.1 Horizontal shaft engines shall be provided with a means for direct attachment of a flexible coupling adaptor, a flexible connecting shaft adaptor, a stub shaft, or a torsional vibration damping type coupling to the engine flywheel. (See Section A.5 and 7.5.1.1.)

11.2.4 Engine Speed Controls.

11.2.4.1 Speed Control Governor.

11.2.4.1.1 Engines shall be provided with a governor capable of regulating engine speed within a range of 10 percent between shutoff and maximum load condition of the pump.

11.2.4.1.2 The governor shall be field adjustable and set and secured to maintain rated pump speed at maximum pump load.

11.2.4.1.3 Engines shall accelerate to rated output speed within 20 seconds.

11.2.4.2* Electronic Fuel Management Control.

11.2.4.2.1 Alternate Electronic Control Module. Engines that incorporate an electronic control module (ECM) to accomplish and control the fuel injection process shall have an alternate ECM permanently mounted and wired so the engine can produce its full rated power output in the event of a failure of the primary ECM.

11.2.4.2.2 ECM Voltage Protection. ECMs shall be protected from transient voltage spikes and reverse dc current.

11.2.4.2.3 ECM Selector Switch.

11.2.4.2.3.1 Operation.

(A) The transition from the primary ECM to the alternate, or alternate to primary shall be controlled by a hand/automatic switch without an off position.

(B) When the switch required in 11.2.4.2.3.1(A) is in the automatic position, the transition from the primary ECM to the

alternate, or alternate to primary shall be accomplished automatically upon failure of either ECM.

(C) When the switch required in 11.2.4.2.3.1(A) is in the hand position, the transition from the primary ECM to the alternate, or from alternate to primary shall be accomplished manually.

11.2.4.2.3.2 Supervision. A visual indicator shall be provided on the engine instrument panel, and a supervisory signal shall be provided to the controller when the ECM selector switch is positioned to the alternate ECM.

11.2.4.2.3.3 Contacts.

(A) The contacts for each circuit shall be rated for both the minimum and maximum current and voltage.

(B) The total resistance of each ECM circuit through the selector switch shall be approved by the engine manufacturer.

11.2.4.2.4 Enclosure.

(A) The selector switch shall be enclosed in a NEMA Type 2 drip-proof enclosure.

(B) Where special environments exist, suitably rated enclosures shall be used.

11.2.4.2.5 Mounting.

(A) The selector switch and enclosure shall be engine mounted.

(B) The selector switch enclosure and/or the selector switch inside shall be isolated from engine vibration to prevent any deterioration of contact operation.

11.2.4.2.4* Engine Power Output. The ECM (or its connected sensors) shall not, for any reason, intentionally cause a reduction in the engine's ability to produce rated power output.

11.2.4.2.5 ECM Sensors. Any sensor necessary for the function of the ECM that affects the engine's ability to produce its rated power output shall have a redundant sensor that shall operate automatically in the event of a failure of the primary sensor.

11.2.4.2.6 ECM Engine Supervision. A common supervisory signal shall be provided to the controller as a minimum for the following events:

- (1) Fuel injection trouble
- (2) Low fuel pressure
- (3) Any primary sensor failure

11.2.4.2.7 ECM and Engine Power Supply.

11.2.4.2.7.1* In the standby mode, the engine batteries or battery chargers shall be used to power the ECM.

11.2.4.2.7.2 Engines shall not require more than 0.5 ampere from the battery or battery charger while the engine is not running.

11.2.4.3 Variable Speed Pressure Limiting Control or Variable Speed Suction Limiting Control (Optional).

11.2.4.3.1 Variable speed pressure limiting control or variable speed suction limiting control systems used on diesel engines for fire pump drive shall be listed for fire pump service and be capable of limiting the pump output total rated head (pressure) or suction pressure by reducing pump speed.

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11.2.4.3.2 Variable speed control systems shall not replace the engine governor as defined in 11.2.1.1.

11.2.4.3.3 In the event of a failure of the variable speed control system, the engine shall operate at pump-rated speed with the governor defined in 11.2.1.1.

11.2.4.3.4 Pressure Sensing Line.

11.2.4.3.4.1 A pressure sensing line shall be provided to the engine with a $\frac{1}{2}$ in. (12.7 mm) nominal size inside diameter line.

11.2.4.3.4.2 For pressure limiting control, a sensing line shall be installed from a connection between the pump discharge flange and the discharge check valve to the engine.

11.2.4.3.4.3 If the pressure sensing line is installed where sediment could enter, a dropdown trap and a cleanout shall be installed.

11.2.4.3.4.4 For suction limiting control, a sensing line shall be installed from a connection at the pump inlet flange to the engine.

11.2.4.3.5 Within 20 seconds after a demand to start, pumps shall supply and maintain a stable discharge pressure (±10 percent) throughout the entire range of operation.

11.2.4.3.5.1 The discharge pressure shall be permitted to stabilize whenever the flow condition changes.

11.2.4.4 Engine Overspeed Shutdown Control, Low Oil Pressure Signal, and High and Low Coolant Temperature Signals.

11.2.4.4.1 Engines shall be provided with an overspeed shutdown device.

11.2.4.4.2 The overspeed device shall be arranged to shut down the engine in a speed range of 10 to 20 percent above rated engine speed and to be manually reset.

11.2.4.4.3 A means shall be provided to indicate an overspeed trouble signal to the automatic engine controller such that the controller cannot be reset until the overspeed shutdown device is manually reset to normal operating position.

11.2.4.4.4 Means shall be provided for verifying overspeed switch and circuitry shutdown function.

11.2.4.4.5 Means shall be provided for signaling critically low oil pressure in the engine lubrication system to the controller.

11.2.4.4.5.1 Means shall be provided on the engine for testing the operation of the oil pressure signal to the controller resulting in visible and common audible alarm on the controller as required in 12.4.1.3.

11.2.4.4.5.2 Instructions for performing the test in 11.2.4.4.5.1 shall be included in the engine manual.

11.2.4.4.6 Means shall be provided for signaling high engine temperature to the controller.

11.2.4.4.6.1 Means shall be provided on the engine for testing the operation of the high engine temperature signal to the controller, resulting in visible and common audible alarm on the controller as required in 12.4.1.3.

11.2.4.4.6.2 Instructions for performing the test in 11.2.4.4.6.1 shall be included in the engine manual.

11.2.4.4.7 Means shall be provided for signaling low engine temperature to the controller.

11.2.4.4.7.1 Means shall be provided on the engine for testing the operation of the low engine temperature signal to the controller, resulting in visible and common audible alarm on the controller as required in 12.4.1.3.

11.2.4.4.7.2 Instructions for performing the test in 11.2.4.4.7.1 shall be included in the engine manual.

11.2.4.4.8 Means shall be provided for signaling high cooling water temperature to the controller at a temperature specified by the engine manufacturer coordinated with the sizing of the heat exchanger water supply.

11.2.4.4.8.1 Means shall be provided on the engine for testing the operation of the high cooling water temperature signal to the controller, resulting in a visible and common audible alarm on the controller as required in 12.4.1.3.

11.2.4.4.8.2 Instructions for performing the test in 11.2.4.4.8.1 shall be included in the engine manual.

11.2.4.5 Engine Running and Crank Termination Control.

11.2.4.5.1 Engines shall be provided with a speed-sensitive switch to signal engine running and crank termination.

11.2.4.5.2 Power for this signal shall be taken from a source other than the engine generator or alternator.

11.2.5 Instrumentation.

11.2.5.1 Instrument Panel.

11.2.5.1.1 All engine instruments shall be placed on a panel secured to the engine or inside an engine base plate-mounted controller.

11.2.5.1.2 The engine instrument panel shall not be used as a junction box or conduit for any supply.

11.2.5.2 Engine Speed.

11.2.5.2.1 A tachometer or other means shall be provided to indicate revolutions per minute of the engine, including zero, at all times.

11.2.5.2.2 The tachometer shall be the totalizing type, or an hour meter or other means shall be provided to record total time of engine operation.

11.2.5.2.3 Tachometers with digital display shall be permitted to be blank when the engine is not running.

11.2.5.3 Oil Pressure. Engines shall be provided with an oil pressure gauge or other means to indicate lubricating oil pressure.

11.2.5.4 Temperature. Engines shall be provided with a temperature gauge or other means to indicate engine coolant temperature at all times.

11.2.5.5 The engine shall be provided with a means to indicate the type of trouble being signaled in 11.2.4.6.

11.2.6 Wiring Diagrams.

11.2.6.1 Automatic Controller Wiring in Factory.

11.2.6.1.1* All connecting wires for automatic controllers shall be harness or flexibly enclosed, mounted on the

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engine, and connected in an engine junction box to terminals numbered to correspond with numbered terminals in the controller.

11.2.6.1.2 All wiring on the engine, including starting circuitry, shall be sized on a continuous-duty basis.

11.2.6.2* Automatic Control Wiring in the Field.

11.2.6.2.1 Interconnections between the automatic controller and the engine junction box shall be made using stranded wire sized on a continuous-duty basis.

11.2.6.2.2 Interconnection wire size shall be based on length as recommended for each terminal by the controller manufacturer.

11.2.6.2.3 The interconnections between the automatic controller and the engine junction box and any at power supply to the engine shall be routed in separate conduits.

11.2.6.3 Battery Cables.

11.2.6.3.1 Battery cables shall be sized in accordance with the engine manufacturer's recommendations considering the cable length required for the specific battery location.

11.2.7 Starting Methods.

11.2.7.1 Storage Devices. Engines shall be equipped with a reliable starting device.

11.2.7.2 Electric Starting. Where electric starting is used, the electric starting device shall take current from a storage battery(ies).

11.2.7.2.1 Batteries.

11.2.7.2.1.1 Each engine shall be provided with two storage battery units.

11.2.7.2.1.2 Lead-acid batteries shall be furnished in a dry charge condition with electrolyte liquid in a separate container.

11.2.7.2.1.3 Nickel-cadmium or other kinds of batteries shall be permitted to be installed in lieu of lead-acid batteries, provided they meet the engine manufacturer's requirements and the charging voltage levels of the chargers in 12.5.3 are twisted to meet the requirements of the specific batteries.

11.2.7.2.1.4 At 40°F (4°C), each battery unit shall have the capacity sufficient to maintain the cranking speed recommended by the engine manufacturer through a 3-minute attempt-to-start cycle, which is six consecutive cranks of 15 seconds of cranking and 15 seconds of rest.

11.2.7.2.1.5 Batteries shall be sized, based on calculations, to have capacity to carry the loads defined in 11.2.7.2.3 for 72 hours of standby power followed by three 15-second attempt-to-start cycles per battery unit as defined in 11.2.7.2.1.4, without at power being available for battery charging.

11.2.7.2.2* Battery Isolation.

11.2.7.2.2.1 Engines with only one cranking motor shall include a main battery controller installed between each battery and the cranking motor for battery isolation.

(A) Main battery controllers shall be listed for fire pump driver service.

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(B) Main battery controllers shall be rated for the cranking motor current.

(C) Main battery controllers shall be capable of manual mechanical operation, including positive methods such as springloaded, momentary contact, to energize the starting motor in the event of controller circuit failure.

11.2.7.2.2.2 Engines with two cranking motors shall have one cranking motor dedicated to each battery.

(A) Each cranking motor shall meet the cranking requirements of a single cranking motor system.

(B) To activate cranking, each cranking motor shall have an integral solenoid relay to be operated by the pump set controller.

(C) Each cranking motor integral solenoid relay shall be capable of being energized from a manual operator listed and rated for the cranking motor solenoid relay and include a mechanical switch on the engine panel to energize the starting motor in the event of controller circuit failure.

11.2.7.2.3 Battery Loads.

11.2.7.2.3.1 Nonessential loads shall not be powered from the engine starting batteries.

11.2.7.2.3.2 Essential loads, including the engine, controller, and all pump room equipment combined, shall not exceed 0.5 amperes each for a total of 1.5 amperes, on a continuous basis.

11.2.7.2.4* Battery Location.

11.2.7.2.4.1 Storage batteries shall be rack supported above the floor, secured against displacement, and located where they will not be subject to excessive temperature, vibration, mechanical injury, or flooding with water.

11.2.7.2.4.2 Current-carrying parts shall not be less than 12 in. (305 mm) above the floor level.

11.2.7.2.4.3 Storage batteries shall be readily accessible for servicing.

11.2.7.2.4.4 Storage batteries shall not be located in front of the engine-mounted instruments and controls.

11.2.7.2.4.5 Storage battery racks and their location shall meet the requirements of NFPA 70.

11.2.7.3 Hydraulic Starting.

11.2.7.3.1 Where hydraulic starting is used, the accumulators and other accessories shall be enclosed or so protected that they are not subject to mechanical injury.

11.2.7.3.2 The enclosure shall be installed as close to the engine as practical so as to prevent serious pressure drop between the engine and the enclosure.

11.2.7.3.3 The diesel engine as installed shall be without starting aid except as required in 11.2.8.2.

11.2.7.3.4 The diesel as installed shall be capable of carrying its full rated load within 20 seconds after cranking is initiated with the intake air, room ambient temperature, and all starting equipment at 32°F (0°C).

11.2.7.3.5 Hydraulic starting means shall comply with the following conditions:

11.2.8 Heat Exchanger Waste Outlet.

11.2.8.1 An outlet shall be provided for the wastewater line from the heat exchanger, and the discharge line shall not be less than one size larger than the inlet line.

11.2.8.2 The outlet line shall be as short as practical, shall provide discharge into a visible open waste cone, and shall have no valves in it.

11.2.8.3 The outlet shall be permitted to discharge to a suction reservoir, provided a visual flow indicator and temperature indicator are installed.

11.2.8.4 When the waste outlet piping is longer than 15 ft (4.6 m) or its outlet discharges are more than 4 ft (1.2 m) higher than the heat exchanger, or both, the pipe size shall be increased by at least one size.

11.2.8.5 Radiators.

11.2.8.5.1 The heat from the primary circuit of a radiator shall be dissipated by air movement through the radiator created by a fan included with, and driven by, the engine.

11.2.8.5.2 The radiator shall be designed to limit maximum engine operating temperature with an inlet air temperature of 120°F (49°C) at the combustion air cleaner inlet.

11.2.8.5.3 The radiator shall include the plumbing to the engine and a flange on the air discharge side for the connection of a flexible duct from the discharge side to the discharge air venturi.

11.2.8.5.4 Fan.

11.2.8.5.4.1 The fan shall push the air through the radiator to be exhausted from the room via the air discharge venturi.

11.2.8.5.4.2 To ensure adequate airflow through the room and the radiator, the fan shall be capable of a 0.5 in. water column (13 mm water column) restriction created by the combination of the air supply and the discharge venturi in addition to the radiator, fan guard, and other engine component obstructions.

11.2.8.5.4.3 The fan shall be guarded for personnel protection.

11.2.9 Engine Lubrication.

11.2.9.1 The engine manufacturer's recommendations for oil heaters shall be followed.

11.3* Pump Room.

11.3.1 The floor or surface around the pump and engine shall be pitched for adequate drainage of escaping water away from critical equipment, such as pump, engine, controller, fuel tank, and so forth.

11.3.2* Ventilation.

11.3.2.1 Ventilation shall be provided for the following functions:

(1) To control the maximum temperature to 120°F (49°C) at the combustion air cleaner inlet with engine running at rated load

(2) To supply air for engine combustion

(3) To remove any hazardous vapors

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(1) The hydraulic cranking device shall be a self-contained system that will provide the required cranking forces and engine starting revolutions per minute (rpm) as recommended by the engine manufacturer.

(2) Electrically operated rechargers shall be used to recharge and maintain the stored hydraulic pressure within the predetermined pressure limits.

(3) The means of automatically maintaining the hydraulic system within the predetermined pressure limits shall be energized from the main bus and the final emergency bus if one is provided.

(4) Engine driven means shall be provided to recharge the hydraulic system when the engine is running.

(5) Means shall be provided to manually recharge the hydraulic system.

(6) The capacity of the hydraulic cranking system shall provide not fewer than six cranking cycles of not less than 15 seconds each.

(7) Each cranking cycle — the first three to be automatic from the signaling system — shall provide the necessary number of revolutions at the required rpm to permit the diesel engine to meet the requirements of carrying its full rated load within 20 seconds after cranking is initiated with intake air, room ambient temperature, and hydraulic cranking system at 32°F (0°C).

(8) The capacity of the hydraulic cranking system sufficient for three starts under conditions described in 11.2.7.3.5(6) shall be held in reserve and arranged so that the operation of a single control by one person will permit the reserve capacity to be employed.

(9) All controls for engine shutdown in the event of overspeed shall be 120 V dc or 24 V dc source to accommodate controls supplied on the engine, and the following also shall apply:

(a) In the event of such failure, the hydraulic cranking system shall provide an interlock to prevent the engine from recharging.

(b) The interlock shall be manually reset for automatic starting when engine failure is corrected.

11.2.7.4 Air Starting.

11.2.7.4.1 In addition to the requirements of Section 11.1 through 11.2.7, 11.2.8.1, 11.2.8 through 11.6.2, 11.6.4, and 11.6.6, the requirements of 11.2.7.4 shall apply.

11.2.7.4.2 Automatic Controller Connections in Factory.

11.2.7.4.2.1 All conduits for automatic controllers shall be harness or flexibly enclosed, mounted on the engine, and connected in an engine junction box to terminals numbered to correspond with numbered terminals in the controller.

11.2.7.4.2.2 These requirements shall ensure ready connection in the field between the two sets of terminals.

11.2.7.4.3 Signal for Engine Running and Crank Termination.

11.2.7.4.3.1 Engines shall be provided with a speed-sensitive switch to signal running and crank termination.

11.2.7.4.3.2 Power for this signal shall be taken from a source other than the engine compressor.

11.2.7.4.4* Air Starting Supply.

11.2.7.4.4.1 The air supply container shall be sized for 180 seconds of continuous cranking without recharging.

11.2.7.4.4.2 There shall be a separate, suitably powered automatic air compressor or means of obtaining air from some other system, independent of the compressor driven by the fire pump engine.

11.2.7.4.4.3 Suitable supervisory service shall be maintained to indicate high and low air pressure conditions.

11.2.7.4.4.4 A bypass conductor with a manual valve or switch shall be installed for direct application of air from the air container to the engine starter in the event of control circuit failure.

11.2.8 Engine Cooling System.

11.2.8.1 The engine cooling system shall be included as part of the engine assembly and shall be one of the following closed-circuit types:

(1) A heat exchanger type that includes a circulating pump driven by the engine, a heat exchanger, and an engine jacket temperature regulating device.

(2) A radiator type that includes a circulating pump driven by the engine, a radiator, an engine jacket temperature regulating device, and an engine-driven fan for providing positive movement of air through the radiator.

11.2.8.2 A means shall be provided to maintain 120°F (49°C) at the combustion chamber.

11.2.8.3 An opening shall be provided in the circuit for filling the system, checking coolant level, and adding makeup coolant when required.

11.2.8.4 The coolant shall comply with the recommendation of the engine manufacturer.

11.2.8.5* Heat Exchanger Water Supply.

11.2.8.5.1 The cooling water supply for a heat exchanger-type system shall be from the discharge of the pump taken off prior to the pump discharge check valve.

11.2.8.5.2 The cooling water flow required shall be set based on the maximum ambient cooling water.

11.2.8.5.3 Heat Exchanger Water Supply Components.

11.2.8.5.3.1 Threaded rigid piping shall be used for this connection.

11.2.8.5.3.2 Nonmetallic flexible sections shall be allowed between the pump discharge and cooling water supply assembly inlet, and between the cooling water supply assembly discharge and engine inlet, provided they have at least 2 times the fire pump discharge rated pressure and have a 30-minute fire resistance rating equal to ISO 15040, *Fire Resistance of Hose Assemblies*.

11.2.8.5.3.3 The pipe connection in the direction of flow shall include an indicating manual shutoff valve, an approved flange-type strainer in addition to the one that can be a part of the pressure regulator, a pressure regulator, an automatic valve, and a second indicating manual shutoff valve or a spring-loaded check valve.

11.2.8.5.3.4 The indicating manual shutoff valves shall have permanent labeling with minimum $\frac{1}{2}$ in. (12.7 mm) text that indicates the following: For the valve in the heat exchanger water supply, "Normal/Open" for the normal open position

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when the controller is in the automatic position and "Caution: Nonautomatic/Closed" for the emergency or manual position.

11.2.8.5.3.5 The pressure regulator shall be of such size and type that it is capable of and adjusted for passing approximately 120 percent of the cooling water required when the engine is operating at maximum brake horsepower and when the regulator is supplied with water at the pressure of the pump when it is pumping at 120 percent of its rated capacity.

11.2.8.5.3.6 Automatic Valve.

(A) An automatic valve listed for fire protection service shall permit flow of cooling water to the engine when it is running.

(B) Energy to operate the automatic valve shall come from the diesel driver or its batteries and shall not come from the building.

(C) The automatic valve shall be normally closed.

(D) The automatic valve shall not be required on a vertical shaft turbine-type pump or any other pump when there is no pressure in the discharge when the pump is idle.

11.2.8.5.3.7 A pressure gauge shall be installed in the cooling water supply system on the engine side of the last valve in the heat exchanger water supply and bypass supply.

11.2.8.5.3.8 Potable Water Separation (Optional). Where two levels of separation for possible contaminants to the ground or potable water source are required by the authority having jurisdiction, dual springloaded check valves or backflow preventers shall be installed.

(A) The springloaded check valve(s) shall replace the second indicating manual shutoff valve(s) in the cooling loop assembly as stated in 11.2.8.5.3.3.

(B) If backflow preventers are used, the devices shall be listed for fire protection service and installed in parallel in the water supply and water supply bypass assembly.

(C) Where the authority having jurisdiction requires the installation of backflow prevention devices in connection with the engine, special consideration shall be given to the increased pressure loss, which will require that the cooling loop pipe size be evaluated and documented by engineering calculations to demonstrate compliance with the engine manufacturer's recommendation.

11.2.8.6* Heat Exchanger Water Supply Bypass.

11.2.8.6.1 A threaded rigid pipe bypass line shall be installed around the heat exchanger water supply.

11.2.8.6.2 The pipe connection in the direction of flow shall include an indicating manual shutoff valve, an approved flange-type strainer in addition to the one that can be a part of the pressure regulator, a pressure regulator, and an indicating manual shutoff valve or a spring-loaded check valve.

11.2.8.6.3 The indicating manual shutoff valves shall have permanent labeling with minimum $\frac{1}{2}$ in. (12.7 mm) text that indicates the following: For the valve in the heat exchanger water supply bypass, "Normal/Closed" for the normal closed position when the controller is in the automatic position and "Emergency/Open" for manual operation or when the engine is overheating.

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(1) To supply and exhaust air as necessary for radiator cooling of the engine when required.

11.3.2.2 The ventilation system components shall be coordinated with the engine operation.

11.3.2.3 Air Supply Ventilator.

11.3.2.3.1 The air supply ventilator shall be considered to include anything in the air supply path to the room.

11.3.2.3.2 The total air supply path to the pump room shall not restrict the flow of the air more than 0.2 in. water column (5.1 mm water column).

11.3.2.4 Air Discharge Ventilator.

11.3.2.4.1 The air discharge ventilator shall be considered to include anything in the air discharge path from the engine to the outdoors.

11.3.2.4.2 The air discharge ventilator shall allow sufficient air to exit the pump room to satisfy 11.3.2.

11.3.2.4.3 Radiator-Cooled Engines.

11.3.2.4.3.1 For radiator-cooled engines, the radiator discharge shall be ducted outdoors in a manner that will prevent recirculation.

11.3.2.4.3.2 The duct shall be attached to the radiator via a flexible section.

11.3.2.4.3.3 The air discharge path for radiator-cooled engines shall not restrict the flow of air more than 0.3 in. water column (7.6 mm water column).

11.3.2.4.3.4 A recirculation duct shall be permitted for cold weather operation provided that the following requirements are met:

- (1) The recirculation airflow shall be regulated by a thermostatically controlled damper.
- (2) The control damper shall fully close in a failure mode.
- (3) The recirculated air shall be ducted to prevent direct recirculation to the radiator.
- (4) The recirculation duct shall not cause the temperature at the combustion air cleaner inlet to rise above 120°F (49°C).
- (5) The bypass shall be installed in such a way as to supply air to the room when needed and when the control damper is open, and not exhaust air from the room.

11.4 Fuel Supply and Arrangement.

11.4.1 General.

11.4.1.1 Plan Review. Before any fuel system is installed, plans shall be prepared and submitted to the authority having jurisdiction for agreement on suitability of the system for prevailing conditions.

11.4.1.2 Fuel Supply Tank.

11.4.1.2.1 The fuel supply tank and fuel shall be reserved exclusively for the fire pump diesel engine.

11.4.1.2.2 There shall be a separate fuel supply tank for each engine.

11.4.1.2.3 There shall be a separate fuel supply and return line for each engine.

11.4.1.3 Fuel Supply Tank Capacity.

11.4.1.3.1 Fuel supply tanks shall have a capacity at least equal to 1 gal per hp (3.07 L per kW), plus 5 percent volume for expansion and 5 percent volume for sludge.

11.4.1.3.2 Whether large-capacity fuel supply tanks are required shall be determined by prevailing conditions, such as refill cycle and fuel heating due to recirculation, and shall be subject to special conditions in each case.

11.4.1.4 Tank Construction.

11.4.1.4.1 Tanks shall be single wall or double wall and shall be designed and constructed in accordance with recognized engineering standards such as ANSI/UL 112, *Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids*.

11.4.1.4.2 Tanks shall be securely mounted on noncombustible supports.

11.4.1.4.3 Tanks used in accordance with the rules of this standard shall be limited in size to 1320 gal (4996 L).

11.4.1.4.3.1 For situations where fuel tanks in excess of 1320 gal (4996 L) are being used, the requirements of NFPA 37 shall apply.

11.4.1.4.4 Single-wall fuel tanks shall be enclosed with a wall, curb, or dike sufficient to hold the entire capacity of the tank.

11.4.1.5 Tank Connections.

11.4.1.5.1 Each tank shall have a fill connection.

11.4.1.5.1.1 Fill pipes that enter the top of the tank shall terminate within 6 in. (152 mm) of the bottom of the tank and shall be installed or arranged so that vibration is minimized.

11.4.1.5.2 Each tank shall have a drain connection.

11.4.1.5.2.1 A drain connection located in the lowest point of the tank shall be 1 in. (25 mm) NPT.

11.4.1.5.3 Each tank shall have a vent connection.

11.4.1.5.3.1 Normal vents shall be 2 in. (50 mm) NPT or sized in accordance with ANSI/UL 112, *Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids*, or other approved standard.

(A) As an alternative to the requirement in 11.4.1.5.3.1, the normal vent shall be at least as large as the largest filling or withdrawal connection, but in no case shall it be less than 1½ in. (38 mm) nominal inside diameter.

11.4.1.5.4 Each tank shall have an engine supply connection.

11.4.1.5.4.1 The fuel supply pipe connection shall be located on a side of the tank.

11.4.1.5.4.2 The engine fuel supply (suction) pipe connection shall be located on the tank so that 5 percent of the tank volume provides a sump volume not usable by the engine.

11.4.1.5.4.3 The tank connection shall be no smaller than the fuel supply piping to the engine.

11.4.1.5.5 Each tank shall have an engine return connection.

11.4.1.5.5.1 The tank connection shall be no smaller than the fuel return piping from the engine.

11.4.1.5.6 Each tank shall have a fuel level switch connection.

11.4.5.3 The grade of fuel shall be indicated on the engine nameplate required in 11.2.2.1.

11.4.5.4 The grade of fuel oil shall be indicated on the fuel tank by letters that are a minimum of 6 in. (152 mm) in height and in contrasting color to the tank.

11.4.5.5 Residual fuels, domestic heating furnace oils, and drained lubrication oils shall not be used.

11.4.6 Static Electricity.

11.4.6.1 The tank, pump, and piping shall be designed and operated to prevent electrostatic ignition.

11.4.6.2 The tank, pump, and piping shall be bonded and grounded.

11.4.6.3 The bond and ground shall be physically applied or shall be inherently present by the nature of the installation.

11.4.6.4 Any electrically isolated section of metallic piping or equipment shall be bonded and grounded to prevent hazardous accumulation of static electricity.

11.5 Exhaust System.

11.5.1 Exhaust Manifold. Exhaust manifolds and turbochargers shall incorporate provisions to avoid hazard to the operator or to flammable material adjacent to the engine.

11.5.2 Exhaust Piping.

11.5.2.1 Each pump engine shall have an independent exhaust system.

11.5.2.2 A flexible connection with a section of stainless steel, seamless or welded corrugated (not interlocked), not less than 12 in. (305 mm) in length, shall be made between the engine exhaust outlet and exhaust pipe.

11.5.2.3 The exhaust pipe shall not be any smaller in diameter than the engine exhaust outlet and shall be as short as possible.

11.5.2.4 The exhaust pipe shall be covered with high-temperature insulation or otherwise guarded to protect personnel from injury.

11.5.2.5 The exhaust pipe and muffler shall be acceptable to the engine manufacturer, and the exhaust back pressure shall not exceed the engine manufacturer's recommendations.

11.5.2.5.1 The exhaust pipe and muffler shall be supported independently of the engine's flexible exhaust connection.

11.5.2.6 Exhaust pipes shall be installed with clearances of at least 9 in. (229 mm) to combustible materials.

11.5.2.7 Exhaust pipes passing directly through combustible roofs shall be guarded at the point of passage by ventilated metal thimbles that extend not less than 9 in. (229 mm) above and 9 in. (229 mm) below roof construction and are at least 6 in. (152 mm) larger in diameter than the exhaust pipe.

11.5.2.8 Exhaust pipes passing directly through combustible walls or partitions shall be guarded at the point of passage by one of the following methods:

- (1) Metal ventilated thimbles not less than 12 in. (305 mm) larger in diameter than the exhaust pipe.
- (2) Metal or buried clay thimbles built in brickwork or other approved materials providing not less than 8 in.

(203 mm) of insulation between the thimble and construction material.

11.5.2.9 Exhaust emission after treatment devices that have the potential to adversely impact the performance and reliability of the engine shall not be permitted.

11.5.2.10 Where required by the authority having jurisdiction, the installation of an exhaust emission after treatment device shall be of the active regeneration type with a pressure limiting device that permits the engine exhaust to bypass the after treatment device when the engine manufacturer's maximum allowed exhaust backpressure is exceeded.

11.5.3 Exhaust Discharge Location.

11.5.3.1 Exhaust from the engine shall be piped to a safe point outside the pump room and arranged to exclude water.

11.5.3.2 Exhaust gases shall not be discharged where they will affect persons or endanger buildings.

11.5.3.3 Exhaust systems shall terminate outside the structure at a point where hot gases, sparks, or products of combustion will discharge to a safe location. [378.2.3.1]

11.5.3.4 Exhaust system terminations shall not be directed toward combustible material or structures, or into atmospheres containing flammable gases, flammable vapors, or combustible dusts. [378.2.3.2]

11.5.3.5 Exhaust systems equipped with spark-arresting mufflers shall be permitted to terminate in Division 2 locations as defined in Article 500 of NFPA 70. [378.2.3.3]

11.6 Diesel Engine Driver System Operation.

11.6.1 Weekly Run.

11.6.1.1 Engines shall be designed and installed so that they can be started no less than once a week and run for no less than 30 minutes to attain normal running temperature.

11.6.1.2 Engines shall run smoothly at rated speed, except for engines addressed in 11.6.1.3.

11.6.1.3 Engines equipped with variable speed pressure limiting controls shall be permitted to run at reduced speeds provided that engine pressure is maintained and they run smoothly.

11.6.2 Engine Maintenance. Engines shall be designed and installed so that they can be kept clean, dry, and well lubricated to ensure adequate performance.

11.6.3 Battery Maintenance.

11.6.3.1 Storage batteries shall be designed and installed so that they can be kept charged at all times.

11.6.3.2 Storage batteries shall be designed and installed so that they can be tested frequently to determine the condition of the battery cells and the amount of charge in the battery.

11.6.3.3 Only distilled water shall be used in battery cells.

11.6.3.4 Battery plates shall be kept submerged at all times.

11.6.3.5 The automatic feature of a battery charger shall not be a substitute for proper maintenance of battery and charger.

11.6.3.6 The battery and charger shall be designed and installed so that periodic inspection of both battery and charger is physically possible.

11.4.1.5.6.1 The fuel tank shall have one 2 in. (50.8 mm) NPT threaded port in the top, near the center, of the tank to accommodate the low fuel level switch required in 11.4.2.

11.4.1.5.7 Each tank shall have an active fuel maintenance return connection.

11.4.1.5.7.1 The fuel tank shall have one minimum 1 in. (25.4 mm) NPT threaded port in the top of the tank to accommodate the connection of a line for the return fuel from an active fuel maintenance system.

11.4.1.5.7.2 Where there is not an active fuel system installed, a plug shall be installed in this connection.

11.4.1.5.8 If a double-wall tank is installed, the interstitial space between the shells of the diesel fuel storage tank shall be monitored for leakage and announced by the engine drive controller. The signal shall be of the supervisory type.

11.4.1.6 Vent Piping.

11.4.1.6.1 Vent piping shall be arranged so that the vapors are discharged upward or horizontally away from adjacent walls and will not be trapped by eaves or other obstructions.

11.4.1.6.2 Outlets shall terminate at least 5 ft (1.5 m) from building openings.

11.4.1.6.3 Outlets shall terminate at least 12 ft (3.7 m) above the finished ground level.

11.4.1.6.4 Vents from interstitial spaces of double-wall tanks shall meet the requirements of 11.4.1.6.2 and 11.4.1.6.3 and shall not be manifolded together with a vent from the primary compartment of the tank.

11.4.2 Tank Level Indication.

11.4.2.1 Means other than sight tubes for continuous indicating of the amount of fuel in each storage tank shall be provided.

11.4.2.2 A fuel level indicator shall be provided to activate at the two-thirds tank level.

11.4.2.3 The low fuel level condition shall initiate a supervisory signal.

11.4.2.4 Tanks shall be prevented from overfilling by one of the following:

- (1) An automatic mechanism that sends an audible or visible signal to the person filling the tank when it reaches 90 percent of the tank's capacity and automatically shuts off the flow of liquid to the tank when it reaches 95 percent of the tank's capacity.
- (2) A permanent sign at the fill point with the tank calibration chart and instructions about the filling procedure, which includes having the person performing the fill operation determine how full the tank is prior to filling and calculate the quantity of fuel (in gallons or liters) that it will take to get the tank to 90 percent of the tank's capacity. Where climatic conditions are such that the sign could be obscured by ice or snow, weathered beyond readability, or otherwise rendered unreadable, the procedures and chart shall be permitted to be located in an office window, lock box, or other location accessible to the person performing the filling of the tank.
- (3) Any approved procedure for preventing the tank from being overfilled.

Chapter 12 Engine Drive Controllers

12.1 Application.

12.1.1 This chapter provides requirements for minimum performance of automatic, automatic diesel engine controllers for diesel engine-driven fire pumps.

12.1.2 Accessory devices, such as fire pump alarm and signaling means, are included where necessary to ensure minimum performance of the equipment mentioned in 12.1.1.

12.1.3 General.

12.1.3.1 All controllers shall be specifically listed for diesel engine-driven fire pump service.

12.1.3.2 All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

12.1.3.3 Markings.

12.1.3.3.1 All controllers shall be marked "Diesel Engine Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation, rated operating pressure, enclosure type designation, and complete electrical rating.

12.1.3.3.2 Where multiple pumps serving different areas or portions of the facility are provided, an appropriate sign shall be conspicuously attached to each controller indicating the area, zone, or portion of the system served by that pump or pump controller.

12.1.4 It shall be the responsibility of the pump manufacturer or its designated representative to make necessary arrangements for the services of a controller manufacturer's representative, where needed, for services and adjustment of the equipment during the installation, testing, and warranty periods.

12.2 Location.

12.2.1 Controllers shall be located as close as is practical to the engines they control and shall be within sight of the engines.

12.2.2 Controllers shall be so located or so protected that they will not be damaged by water escaping from pumps or pump connections.

12.2.3 Current carrying parts of controllers shall not be less than 12 in. (305 mm) above the floor level.

12.2.4 Working clearances around controllers shall comply with NFPA 70, Article 110.

12.3 Construction.

12.3.1 Equipment.

12.3.1.1 All equipment shall be suitable for use in locations subject to a moderate degree of moisture, such as a damp basement.

12.3.1.2 Reliability of operation shall not be adversely affected by normal dust accumulations.

12.3.2 Mounting. All equipment not mounted on the engine shall be mounted in a substantial manner on a single noncombustible supporting structure.

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12.5.3 Enclosures.

12.5.3.1* Mounding.

12.5.3.1.1 The structure or panel shall be securely mounted in, as a minimum, a NEMA Type 2 drip-proof enclosure(s) or an enclosure(s) with an ingress protection (IP) rating of IP 31.

12.5.3.1.2 Where the equipment is located outside or special environments exist, suitably rated enclosures shall be used.

12.5.3.2 Grounding. The enclosures shall be grounded in accordance with NFPA 70, Article 250.

12.5.3.3 Locked Lockable Cabinet. All switches required to keep the controller in the automatic position shall be within locked enclosures having breakable glass panels.

12.5.3 Connections and Wiring.

12.5.3.1 Field Wiring.

12.5.3.1.1 All wiring between the controller and the diesel engine shall be stranded and sized to carry the charging or control currents as required by the controller manufacturer.

12.5.3.1.2 Such wiring shall be protected against mechanical injury.

12.5.3.1.3 Controller manufacturer's specifications for distance and wire size shall be followed.

12.5.3.2 Wiring Elements. Wiring elements of the controller shall be designed on a consistency basis.

12.5.3.3 Field Connections.

12.5.3.3.1 A diesel engine fire pump controller shall not be used as a junction box to supply other equipment.

12.5.3.3.2 No external controls or changes to the controller that interfere with the operation of the controller shall be installed.

12.5.3.3.3 Electrical supply conductors for pressure maintenance (jockey or make-up) pumps shall not be connected to the diesel engine fire pump controller.

12.5.3.3.4 Except as provided in 12.02.25, remote shutdown or interlock to prevent normal operation shall not be permitted unless approved by the authority having jurisdiction.

12.5.3.3.5 Diesel engine fire pump controllers shall be permitted to supply essential and necessary air or oil power, or both, to operate pump room dampers and engine oil heaters and other associated engine equipment only when provided with factory-equipped dedicated field terminals and overcurrent protection.

12.5.6 Electrical Diagrams and Instructions.

12.5.6.1 A field connection diagram shall be provided and permanently attached to the inside of the enclosure.

12.5.6.2 The field connection terminals shall be plainly marked to correspond with the field connection diagram furnished.

12.5.6.3 For external engine connections, the field connection terminals shall be commonly numbered between the controller and the engine terminals.

12.5.6.4 The installation instructions of the manufacturer of the fire pump controller shall be followed.

12.5.7 Marking.

12.5.7.1 Each operating component of the controller shall be plainly marked with the identification symbol that appears on the electrical schematic diagram.

12.5.7.2 The markings shall be located so as to be visible after installation.

12.5.8* Instructions. Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

12.6 Components.

12.6.1 Indicators on Controller.

12.6.1.1 All visible indicators shall be plainly visible.

12.6.1.2* Visible indication shall be provided to indicate that the controller is in the automatic position. If the visible indicator is a pilot lamp, it shall be accessible for replacement.

12.6.1.3 Separate visible indicators and a common audible fire pump alarm capable of being heard while the engine is running and operable in all positions of the main switch except the off position shall be provided to immediately indicate the following conditions:

- (1) Critically low oil pressure in the lubrication system
- (2) High engine temperature
- (3) Failure of engine to start automatically
- (4) Shutdown from overvoltage
- (5) High cooling water temperature

12.6.1.3.1 The controller shall provide means for testing the low oil pressure alarms and circuit in conjunction with the engine circuit testing method.

12.6.1.3.2 Instructions shall be provided on how to test the operation of the signals in 12.6.1.3.

12.6.1.4 Separate visible indicators and a common audible signal capable of being heard while the engine is running and operable in all positions of the main switch except the off position shall be provided to immediately indicate the following conditions:

- (1)* Battery failure or missing battery. Each controller shall be provided with a separate visible indicator for each battery. The battery failure signal shall initiate at no lower than two-thirds of battery nominal voltage rating (8.0 V dc on a 12 V dc system). Sensing shall be delayed to prevent nuisance signals.
- (2) Battery charger failure. Each controller shall be provided with a separate visible indicator for battery charger failure and shall not require the audible signal for battery charger failure.
- (3) Low air or hydraulic pressure. Where air or hydraulic starting is provided (see 11.2.7.2 and 11.2.7.4), each pressure tank shall provide to the controller separate visible indicators to indicate low pressure.
- (4) System overpressure, for engines equipped with variable speed pressure limiting controls, to actuate at 115 percent of set pressure.
- (5) ECM selector switch in alternate ECM position (only for engines with ECM control only).

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- (6)* Common alarm for fuel injection malfunction (only for engines with ECM control).
- (7) Low fuel level. Signal at two-thirds tank capacity.
- (8) Low air pressure (air-starting engine controllers only). The air supply container shall be provided with a separate visible indicator to indicate low air pressure.
- (9) Low engine temperature.
- (10) Supervisory signal for interstitial space liquid intrusion.
- (11) High cooling water temperature.
- (12) Fuel maintenance needed if automatic fuel maintenance system is provided.

12.6.1.5 A separate signal-silencing switch or valve, other than the controller main switch, shall be provided for the conditions reflected in 12.6.1.3 and 12.6.1.4.

12.6.1.5.1 The switch or valve shall allow the audible device to be silenced for up to 1 hours and then resound repeatedly for the conditions in 12.6.1.3.

12.6.1.5.2 The switch or valve shall allow the audible device to be silenced for up to 24 hours and then resound repeatedly for the conditions in 12.6.1.4.

12.6.1.5.3 The audible device shall re-sound until the condition is corrected or the main switch is placed in the off position.

12.6.1.6 The controller shall automatically return to the non-silenced state when the alarm(s) have cleared (returned to normal).

12.6.1.7 Where audible signals for the additional conditions listed in 12.6.1.3 are incorporated with the engine fire pump alarm specified in 12.6.1.3, a silencing switch or valve for the additional A.4.25 audible signals shall be provided at the controller.

12.6.1.8 The circuit shall be arranged so that the audible signal will be actuated if the silencing switch or valve is in the silent position when the supervised conditions are normal.

12.6.2 Signal Devices Remote from Controller.

12.6.2.1 Where the pump room is not constantly attended, audible or visible signals powered by a source other than the engine starting batteries and not exceeding 125 V shall be provided at a point of constant attendance.

12.6.2.2 Remote Indication. Controllers shall be equipped to operate circuits for remote indication of the conditions covered in 12.6.1.3, 12.6.1.4, and 12.6.1.5.

12.6.2.3 The remote panel shall indicate the following:

- (1) The engine is running (separate signal).
- (2) The controller main switch has been turned to the off or manual position (separate signal).
- (3) There is trouble on the controller or engine (separate or common signal). (See 12.6.1.4 and 12.6.1.5.)

12.6.2.4 Controller Controls for Remote Indication. Controllers shall be equipped with open or closed contacts to operate circuits for the conditions covered in 12.6.2.

12.6.4* Pressure Recorder.

12.6.4.1 A low-pressure recording device shall be installed to sense and record the pressure in each fire pump controller pressurizing line at the input to the controller.

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12.6.4.2 The recorder shall be capable of operating for at least 7 days without being reset or reloaded.

12.6.4.3 The pressure-sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least 480 psi (27.6 bar) or 135 percent of fire pump controller rated operating pressure, whichever is higher, without losing its accuracy.

12.6.4.4 The pressure recording device shall be spring wound mechanically or driven by reliable electrical means.

12.6.4.5 The pressure recording device shall not be solely dependent upon alternating current (ac) electric power as its primary power source.

12.6.4.6 Upon loss of ac electric power, the electric-driven recorder shall be capable of at least 24 hours of operation.*

12.6.4.7 In a non-pressure-actuated controller, the pressure recorder shall not be required.

12.6.5 Voltmeter. A voltmeter with an accuracy of 25 percent shall be provided for each battery bank to indicate the voltage during cranking or to monitor the condition of batteries used with air-starting engine controllers.

12.5.7* Battery Recharging.

12.5.7.1 Two means for recharging storage batteries shall be provided.

12.5.7.2 One method shall be the generator or alternator furnished with the engine.

12.5.7.3 The other method shall be an automatically controlled charger taking power from an ac power source.

12.5.8 If an ac power source is not available or is not reliable, another charging method in addition to the generator or alternator furnished with the engine shall be provided.

12.6 Battery Chargers. The requirements for battery chargers shall be as follows:

- (1) Chargers shall be specifically listed for fire pump service and be part of the diesel fire pump controller.
- (2) Additional chargers also listed for fire pump service shall be permitted to be installed external to the diesel fire pump controller for added capacity or redundancy.
- (3) The charger shall be a semiconductor type.
- (4) The charger for a lead-acid battery shall be a type that automatically reduces the charging rate to less than 500 mA when the battery reaches a full charge condition.
- (5) The battery charger at its rated voltage shall be capable of delivering energy into a fully discharged battery in such a manner that it will not damage the battery.
- (6) The battery charger shall restore to the battery 100 percent of the battery's reserve capacity or ampere-hour rating within 24 hours.
- (7) The charger shall be marked with the reserve capacity or ampere-hour rating of the largest capacity battery that it can recharge in compliance with 12.6.4.
- (8) An ammeter with an accuracy of 25 percent of the normal charging rate shall be furnished to indicate the operation of the charger.
- (9) The charger shall be designed such that it will not be damaged or blow fuses during the cranking cycle of the

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engine when operated by an automatic or manual controller.

(10) The charger shall automatically charge at the maximum rate whenever required by the state of charge of the battery.

(11) The battery charger shall be arranged to indicate low of current output on the load side of the direct current (dc) overcurrent protective device when not connected through a control panel. (See 12.4.4.1(2).)

(12) The charger(s) shall remain in float mode or switch from equalize to float mode while the batteries are under the loads in 12.5.2.

12.7* Starting and Control.

12.7.1 Automatic and Nonautomatic.

12.7.1.1 An automatic controller shall be operable also as a nonautomatic controller.

12.7.1.2 The controller's primary source of power shall not be ac electric power.

12.7.2 Automatic Operation of Controller.

12.7.2.1 Water Pressure Control.

12.7.2.1.1 Pressure-Actuated Switch.

12.7.2.1.1.1 A pressure-actuated switch or electronic pressure sensor having adjustable high- and low-calibrated setpoints as part of the controller shall be provided.

12.7.2.1.1.2 For multistage multipoint pumps, a dedicated pressure-actuated switch or electronic pressure sensor as described in 12.7.2.1.1.1 shall be provided for each discharge port of the pump as part of the controller.

12.7.2.1.1.3 For multistage multipoint pumps, a dedicated pressure recorder as described in 12.6.4.1 shall be provided for each discharge port of the pump as part of the controller.

12.7.2.1.1.4 The requirements of 12.7.2.1.1.1 and 12.7.2.1.1.2 shall not apply to a non-pressure-actuated controller, where the pressure-actuated switch or pressure responsive means shall not be required.

12.7.2.1.2 There shall be no pressure sensor or reactive device employed within the pressure switch or pressure responsive means.

12.7.2.1.3* Where an electronic pressure sensor is used to automatically start fire pump operation, the fire pump controller shall monitor the transducer during automatic testing.

12.7.2.1.3.1* When the transducer pressure reading exceeds 10 psi (0.68 bar) during any automatic pump start where initiated by the solenoid drain valve as required by 12.7.2.7.3, the controller shall activate a visual and audible alarm that can be silenced.

12.7.2.1.3.2* Where an electronic pressure sensor is used to control fire pump operation, the fire pump controller shall monitor for and provide a signal for the following electronic pressure sensor conditions:

- (1) Any time the transducer output is less than 10 percent of rated span or below rated zero pressure output
- (2) Any time the pressure transducer reading is more than 10 percent above its rated full-scale output

12.7.2.1.4 There shall be no valve or other restrictions within the controller ahead of the pressure switch or pressure responsive means.

12.7.2.1.5 This switch shall be responsive to water pressure in the fire protection system.

12.7.2.1.6 The pressure sensing element of the switch shall be capable of a momentary surge pressure of 480 psi (27.6 bar) or 135 percent of fire pump controller rated operating pressure, whichever is higher, without losing its accuracy.

12.7.2.1.7 Suitable provision shall be made for relieving pressure to the pressure-actuated switch to allow testing of the operation of the controller and the pumping unit. (See Figure A.3.1(a) and Figure A.3.1(b).)

12.7.2.1.8 Water pressure control shall be as follows:

- (1) There shall be no shutoff valve in the pressure sensing line.
- (2) Pressure switch actuation at the low adjustment setting shall initiate the pump starting sequence if the pump is not already in operation.

12.7.2.2 Fire Protection Equipment Control.

12.7.2.2.1 Where the pump supplies special water control equipment (e.g., deluge valves, drypipe valves), the engine shall be permitted to start before the pressure-actuated switch(es) would do so.

12.7.2.2.2 Under such conditions, the controller shall be equipped to start the engine upon operation of the fire protection equipment.

12.7.2.2.3 Starting of the engine shall be initiated by the opening of the control circuit loop containing this fire protection equipment.

12.7.2.3 Manual Electric Control at Remote Station. Where additional control stations for causing nonautomatic continuous operation of the pumping unit, independent of the pressure-actuated switch or control valve, are provided at locations remote from the controller, such stations shall not be operable to stop the engine.

12.7.2.4 Automatic starting upon loss of ac power shall not be permitted unless required by the authority having jurisdiction.

12.7.2.5 Sequence Starting of Pumps.

12.7.2.5.1 The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one driver from starting simultaneously with any other driver.

12.7.2.5.2 Each pump supplying water pressure to another pump shall be arranged to start within 10 seconds before the pump it supplies.

12.7.2.5.3 The controllers for pumps arranged in series shall be interlocked to ensure the correct pump starting sequence.

12.7.2.5.4 If water requirements call for more than one pump unit to operate, the units shall start at intervals of 5 to 10 seconds.

12.7.2.5.5 Failure of a leading driver to start shall not prevent subsequent drivers from starting.

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12.7.2.6 External Circuits Connected to Controllers.

12.7.2.6.1 With pumping units operating singly or in parallel, the control conductors entering or leaving the fire pump controller and extending outside the fire pump room shall be so arranged as to prevent failure to start due to fault.

12.7.2.6.2 Breakage, disconnection, shorting of the wires, or loss of power to these circuits shall be permitted to cause continuous running of the fire pump but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits.

12.7.2.6.3 All control conductors within the fire pump room that are not fault tolerant shall be protected against mechanical injury.

12.7.2.6.4 When a diesel driver is used in conjunction with a positive displacement pump, the diesel controller shall provide a circuit and timer to actuate and then close the dump valve after engine start is finished.

12.7.2.7 Automatic Testing.

12.7.2.7.1 The controller equipment shall be arranged to automatically start, run, and shut down the engine at the minimum no-load test frequency and duration required by NFPA 25.

12.7.2.7.2 Performance of this weekly program timer shall be recorded as a pressure drop indication on the pressure recorder. (See 12.6.4.1.)

12.7.2.7.3 A solenoid valve drain on the pressure control line shall be the initiating means.

12.7.2.7.4 The engine shall shut down automatically on high engine temperature, low oil pressure, or high cooling water temperature if no other starting or running cause exists.

12.7.2.7.5 If after shutdown a starting cause occurs, the controller shall restart the engine and override the high engine temperature, low oil pressure, or high cooling water temperature shutdown and run in accordance with 12.7.2.2.

12.7.2.7.6 In a non-pressure-actuated controller, the weekly test shall be permitted to be initiated by means other than a solenoid valve.

12.7.2.7.7 The controller shall use the opposite battery bank (every other bank) for cranking on subsequent weeks.

12.7.3 Nonautomatic Operation of Controller.

12.7.3.1 Manual Control at Controller.

12.7.3.1.1 There shall be a manually operated switch or valve on the controller panel.

12.7.3.1.2 This switch or valve shall be so arranged that operation of the engine, when manually started, cannot be affected by the pressure-actuated switch.

12.7.3.1.3 The arrangement shall also provide that the unit will remain in operation until manually shut down.

12.7.3.1.4 Failure of any of the automatic circuits shall not affect the manual operation.

12.7.3.2 Manual Testing of Automatic Operation.

12.7.3.2.1 The controller shall be arranged to manually start the engine by opening the solenoid valve drain when so initiated by the operator.

12.7.3.2.2 In a non-pressure-actuated controller, the manual test shall be permitted to be initiated by means other than a solenoid valve.

12.7.4 Starting Equipment Arrangement. The requirements for starting equipment arrangement shall be as follows:

- (1) Two storage battery units, each complying with the requirements of 12.7.2.1, shall be provided and so arranged that manual and automatic starting of the engine can be accomplished with either battery.
- (2) The starting current shall be furnished by first one battery and then the other on successive operations of the starter.
- (3) The battery charger(s) shall be made automatically, except for manual start.
- (4) In the event that the engine does not start after completion of its attempt-to-start cycle, the controller shall stop all further cranking and operate a visible indicator and audible fire pump alarm on the controller.
- (5) The attempt-to-start cycle shall be fixed and shall consist of six crank periods of approximately 15-second duration separated by five rest periods of approximately 15-second duration.
- (6) In the event that one battery is inoperative or missing, the control shall lock in on the remaining battery unit during the cranking sequence.

12.7.5 Methods of Stopping.

12.7.5.1 Manual Electric Shutdown. Manual shutdown shall be accomplished by either of the following:

- (1) Operation of the main switch or stop valve inside the controller.
- (2) Operation of a stop button or stop valve on the outside of the controller enclosure as follows:
 - (a) The stop button or stop valve shall cause engine shutdown through the automatic circuits only if all starting causes have been returned to normal.
 - (b) The controller shall then return to the full automatic position.

12.7.5.2* Automatic Shutdown After Automatic Start. Automatic shutdown shall not be permitted if starting and running causes are present.

12.7.5.3 Automatic shutdown shall be permitted only in the following circumstances:

- (1)* During automatic testing in accordance with 12.7.2.7.
- (2) When the engine overvoltage shutdown device operates:
 - (a) The controller shall remove power from the engine running devices, prevent further cranking, energize the overvoltage fire pump alarm, and lock out until manually reset.
 - (b) Resetting of the overvoltage circuit shall be required at the engine and by resetting the controller main switch to the off position.
 - (c) The controller shall not be capable of being reset until the engine overvoltage shutdown device is manually reset.

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- (5) Where approved by the authority having jurisdiction.
- 12.7.5.2.2*** Where automatic shutdown after automatic start is permitted, a minimum run timer set for at least 30 minutes shall be used.
- 12.7.6 Emergency Control.** Automatic control circuits, the failure of which could prevent engine starting and running, shall be completely bypassed during manual start and run.
- 12.8 Air-Starting Engine Controllers.**
- 12.8.1 Existing Requirements.** In addition to the requirements in Sections 12.1 through 12.7, the requirements in Section 12.8 shall apply.
- 12.8.2 Starting Equipment Arrangement.** The requirements for starting equipment arrangement shall be as follows:
- (1) The air supply container, complying with the requirements of 11.2.7.4.4, shall be provided and so arranged that manual and automatic starting of the engine can be accomplished.
 - (2) In the event that the engine does not start after completion of its attempt-to-start cycle, the controller shall stop all further cranking and operate the audible and visible fire pump alarm.
 - (3) The attempt-to-start cycle shall be fixed and shall consist of one crank period of an approximately 90-second duration.
- 12.8.3 Manual Shutdown.** Manual shutdown shall be accomplished by either of the following:
- (1) Operation of a stop valve or switch on the controller panel
 - (2) Operation of a stop valve or switch on the outside of the controller enclosure
- 12.8.3.1** The stop valve shall cause engine shutdown through the automatic circuits only after starting causes have been returned to normal.
- 12.8.3.2** This action shall return the controller to full automatic position.

Chapter 13 Steam Turbine Drive

- 13.1 General.**
- 13.1.1 Acceptability.**
- 13.1.1.1** Steam turbines of adequate power are acceptable prime movers for driving fire pumps.
- 13.1.1.1.1** Reliability of the turbines shall have been proved in commercial work.
- 13.1.1.2** The steam turbine shall be directly connected to the fire pump.
- 13.1.2 Turbine Capacity.**
- 13.1.2.1** For steam boiler pressures not exceeding 120 psi (8.3 bar), the turbine shall be capable of driving the pump at its rated speed and maximum pump load with a pressure as low as 80 psi (5.5 bar) at the turbine throttle when exhausting against atmospheric back pressure with the hand valve open.
- 13.1.2.2** For steam boiler pressures exceeding 120 psi (8.3 bar), where steam is continuously maintained, a pressure

- 70 percent of the usual boiler pressure shall take the place of the 80 psi (5.5 bar) pressure required in 13.1.2.1.
- 13.1.2.3** In ordering turbines for stationary fire pumps, the purchaser shall specify the rated and maximum pump loads at rated speed, the rated speed, the boiler pressure, the steam pressure at the turbine throttle (if possible), and the steam superheat.
- 13.1.3* Steam Consumption.**
- 13.1.3.1** Prime consideration shall be given to the selection of a turbine having a total steam consumption commensurate with the steam supply available.
- 13.1.3.2** Where multistage turbines are used, they shall be so designed that the pump can be brought up to speed without a warmup time requirement.
- 13.2 Turbine.**
- 13.2.1 Casing and Other Parts.**
- 13.2.1.1*** The casing shall be designed to permit access with the least possible removal of parts or piping.
- 13.2.1.2** A safety valve shall be connected directly to the turbine casing to relieve high steam pressure in the casing.
- 13.2.1.3 Main Throttle Valve.**
- 13.2.1.3.1** The main throttle valve shall be located in a horizontal run of pipe connected directly to the turbine.
- 13.2.1.3.2** There shall be a water leg on the supply side of the throttle valve.
- 13.2.1.3.3** This leg shall be connected to a suitable steam trap to automatically drain all condensate from the line supplying steam to the turbine.
- 13.2.1.3.4** Steam and exhaust chambers shall be equipped with suitable condensate drains.
- 13.2.1.3.5** Where the turbine is automatically controlled, these drains shall discharge through adequate traps.
- 13.2.1.3.6** In addition, if the exhaust pipe discharges vertically, there shall be an open drain at the bottom elbow.
- 13.2.1.3.7** This drain shall not be valued but shall discharge to a safe location.
- 13.2.1.4** The nozzle chamber, governor body, pressure regulator, and other parts through which steam passes shall be made of a metal able to withstand the maximum temperatures involved.
- 13.2.2 Speed Governor.**
- 13.2.2.1** The steam turbine shall be equipped with a speed governor set to maintain rated speed at maximum pump load.
- 13.2.2.2** The governor shall be capable of maintaining, at all loads, the rated speed within a total range of approximately 8 percent from no turbine load to full-rated turbine load by either of the following methods:
- (1) With normal steam pressure and with hand valve closed.
 - (2) With steam pressure down to 80 psi (5.5 bar) (or down to 70 percent of full pressure where this is in excess of 120 psi (8.3 bar)) and with hand valve open

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Chapter 14 Acceptance Testing, Performance, and Maintenance

14.1 Hydrostatic Tests and Flushing

- 14.1.1* Flushing.**
- 14.1.1.1** Suction piping shall be flushed at a flow rate not less than indicated in Table 14.1.1.1 or at the hydraulically calculated water demand rate of the system, whichever is greater.
- 14.1.1.2** Flushing shall occur prior to hydrostatic test.
- 14.1.1.3** Where the maximum flow available from the water supply cannot provide the flow rate provided in Table 14.1.1.1, the flushing flow rate shall be equal to or greater than 150 percent of rated flow of the connected fire pump.
- 14.1.1.3.1** Where the maximum flow available from the water supply cannot provide a flow of 150 percent of the rated flow of the pump, the flushing flow rate shall be the greater of 100 percent of rated flow of the connected fire pump or the maximum flow demand of the fire protection system.
- 14.1.1.3.2** A reduced flushing flow capacity in accordance with 14.1.1.3.1 shall constitute an acceptable test, provided that the flow rate is as much as can be safely achieved and it exceeds the fire protection system design flow rate.

14.1.2 Hydrostatic Test.

- 14.1.2.1** Suction and discharge piping shall be hydrostatically tested at not less than 200 psi (13.8 bar) pressure or at 50 psi (3.4 bar) in excess of the maximum pressure to be maintained in the system, whichever is greater.
- 14.1.2.2** The pressure required in 14.1.2.1 shall be maintained for 2 hours.
- 14.1.3*** The installing contractor shall furnish a certificate for flushing and hydrostatic test prior to the start of the fire pump field acceptance test.

14.2 Field Acceptance Tests.

- 14.2.1*** The pump manufacturer, the engine manufacturer (when supplied), the controller manufacturer, and the transfer switch manufacturer (when supplied) or their factory-authorized representatives shall be present for the field acceptance test. (See Section 1.4.)

Table 14.1.1.1 Minimum Flow Rates for Flushing Suction Piping

Nominal Pipe Size (in.)	Flow rate (gpm)	Nominal Pipe Size (mm)	Flow Rate (L/min)
1½	85	38	345
2	150	50	540
3	330	75	1,360
4	590	100	2,160
6	920	125	3,490
8	1,340	150	4,850
10	2,500	200	8,900
12	3,670	250	13,900
14	5,290	300	20,000

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- 14.2.2** The date, time, and location of the field acceptance test shall be coordinated with the authority having jurisdiction.
- 14.2.3 Pump Room Electrical Wiring.** All electric wiring to the fire pump motor(s), including control (multiple pumps) interlocking, normal power supply, alternate power supply where provided, and jockey pump, shall be completed and checked by the electrical contractor prior to the initial startup and acceptance test.
- 14.2.4* Certified Pump Curve.**
- 14.2.4.1** A copy of the manufacturer's certified pump test curve shall be available for comparison with the results of the field acceptance test.
- 14.2.4.1.1** For water mist positive displacement pumping units, a copy of the manufacturer's certified shop test data for both variable speed and nonvariable speed operation shall be available for comparison of the results of the field acceptance test.
- 14.2.4.1.2** For multistage multipump pumps, a copy of the manufacturer's certified shop test data for each discharge outlet shall be available for comparison with the results of the field acceptance test.
- 14.2.4.2** At all flow conditions, including those required to be tested in 14.2.6.2, the fire pump as installed shall equal the performance as indicated on the manufacturer's certified shop test curve within the accuracy limits of the test equipment.
- 14.2.4.2.1** For water mist positive displacement pumping units with variable speed features, the pump unit as installed shall equal the performance as indicated on the fire pump unit manufacturer's certified shop test data, with variable speed features deactivated within the accuracy limits of the test equipment.
- 14.2.4.2.2** For water mist positive displacement pumping units, the pump unit as installed shall equal the performance as indicated on the fire pump unit manufacturer's certified shop test data, with variable speed features activated within the accuracy limits of the test equipment.
- 14.2.5 System Demand.** The actual unaltered fire pump discharge flow and pressures localized shall meet or exceed the fire protection system's demand.
- 14.2.6* Field Acceptance Test Procedures.**
- 14.2.6.1* Test Equipment.**
- 14.2.6.1.1** Calibrated test equipment shall be provided to determine net pump pressures, rate of flow through the pump, volts and amperes, and speed.
- 14.2.6.1.2** Calibrated test gauges, transducers, and other devices used for measurements required in 14.2.6.1.1 during the test shall be used and shall bear a label with the latest date of calibration.
- 14.2.6.1.2.1** Gauges, transducers, and other devices used for measurements required in 14.2.6.1.1 during the test shall be calibrated annually at minimum.
- 14.2.6.1.2.2** Calibration of gauges, transducers, and other devices used for measurements required in 14.2.6.1.1 during the test shall be maintained at an accuracy level of ± 1 percent.

- 14.2.6.1.2.3** Fire pump controller voltage and current readings on controllers that are factory calibrated and adjusted to ± 3 percent shall be permitted to be used in lieu of calibrated voltmeter and ammeter for the acceptance test.
- 14.2.6.1.2.4** Fixed outlet flow devices shall be inspected for damage, but they shall not require calibration.
- 14.2.6.1.3** Discharge and sensing orifices that can be visually observed without disassembling equipment, piping, or valves shall be visually inspected and shall be free of damage and obstructions that could affect the accuracy of the measurement.
- 14.2.6.1.4** Discharge orifices shall be listed or constructed to a recognized standard with a known discharge coefficient.
- 14.2.6.1.5** Requirements for personal protective equipment and procedures in accordance with NFPA 70E shall be followed when working near energized electrical or rotating equipment.
- 14.2.6.2 Fire Pump Flow Testing(s).**
- 14.2.6.2.1** The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component.
- 14.2.6.2.2** Vibrations of the fire pump assembly shall not be of a magnitude to pose potential damage to any fire pump component.
- 14.2.6.2.3** The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices.
- 14.2.6.2.3.1** Where simultaneous operation of multiple pumps is possible or required as part of a system design, the acceptance test shall include a flow test of all pumps operating simultaneously.
- 14.2.6.2.4** Where the maximum flow available from the water supply cannot provide a flow of 150 percent of the rated flow of the pump, the fire pump shall be operated at the greater of 100 percent of rated flow or the maximum flow demand of the fire protection system(s) maximum allowable discharge to determine its acceptance.
- 14.2.6.2.4.1** This reduced capacity shall constitute an acceptable test, provided that the pump discharge exceeds the fire protection system design and flow rate.
- 14.2.6.2.5** Where the suction to the fire pump is from a break tank, the tank refill rate shall be tested and recorded.
- 14.2.6.2.5.1** The refill device shall be operated a minimum of five times.
- 14.2.6.2.6 Water Level Detection.** Water level detection shall be required for all vertical turbine pumps installed in wells to determine the water level available at the shafthead the 100 percent and 150 percent flow points, to determine if the pump is operating within its design conditions.
- 14.2.6.2.6.1** The distance between the water level and the discharge flange shall be used to determine the net discharge pressure of the pump to prove the pump's performance.
- 14.2.6.3 Variable Speed Pressure Limiting Control.**
- 14.2.6.3.1** Pumps with variable speed pressure limiting control shall be tested at no-flow, 25 percent, 50 percent, 75 percent,

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- 100 percent, 125 percent, and 150 percent of rated load in the variable speed mode.
- 14.2.6.3.1.1** They shall also be tested at minimum, rated, and peak loads, with the fire pump operating at rated speed.
- 14.2.6.3.2** The fire protection system shall be isolated and the pressure relief valve closed for the rated speed test required in 14.2.6.3.1.1.
- 14.2.6.3.3** The fire protection system shall be open and the relief valve set for the variable speed tests required in 14.2.6.3.1.
- 14.2.6.4 Multistage Multipump Pumps.**
- 14.2.6.4.1** Each discharge outlet on a multistage multipump fire pump shall be tested in accordance with this standard.
- 14.2.6.5* Measurement Procedure.**
- 14.2.6.5.1** The quantity of water discharging from the fire pump assembly shall be determined and stabilized.
- 14.2.6.5.2** Immediately thereafter, the operating conditions of the fire pump and driver shall be measured.
- 14.2.6.5.3 Positive Displacement Pumps.**
- 14.2.6.5.3.1** The pump flow for positive displacement pumps shall be tested and determined to meet the specified rated performance criteria where only one performance point is required to establish positive displacement pump acceptability.
- 14.2.6.5.3.2** The pump flow test for positive displacement pumps shall be accomplished using a flowmeter or orifice plate installed in a test loop back to the supply tank, to the inlet side of a positive displacement water pump, or to drain.
- 14.2.6.5.3.3** The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer's flow performance data.
- 14.2.6.5.3.4** If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side of the orifice plate shall be made available to the authority having jurisdiction.
- 14.2.6.5.3.5** Flow rates that be as specified while operating at the system design pressure. Tests shall be performed in accordance with 11.1.3.6, *Flow Pump Tests*.
- 14.2.6.5.3.6** Positive displacement pumps intended to pump liquids other than water shall be permitted to be tested with water; however, the pump performance will be affected, and manufacturer's calculations shall be provided showing the difference in viscosity between water and the liquid pumped.
- 14.2.6.5.3.7** For water mist positive displacement pumping units, each pump shall be operated manually a minimum of six times during the acceptance test.
- 14.2.6.5.3.8** For water mist positive displacement pumping units, each of the required automatic operations shall operate all pumps, except as provided in 14.2.6.5.3.9 and 14.2.6.5.3.10.
- 14.2.6.5.3.9** Where redundant pumps are provided, each of the automatic operations shall operate the number of pumps required to meet system demand.

- 14.2.6.5.3.10** Where redundant pumps are provided, each pump shall operate for a minimum of three automatic operations.
- 14.2.6.5.4 Electric Motor-Driven Units.** For electric motors operating at rated voltage and frequency, the ampere demand on each phase shall not exceed the product of the full-load ampere rating times the allowable service factor as stamped on the motor nameplate.
- 14.2.6.5.5*** For electric motors operating under varying voltage, the product of the actual voltage and current demand on each phase shall not exceed the product of the rated voltage and rated full-load current times the allowable service factor.
- 14.2.6.5.6** The voltage at the motor contactor output lugs shall not vary more than 5 percent below or 10 percent above rated (nameplate) voltage during the test. (See Section 9.4.)
- 14.2.6.5.7 Engine-Driven Units.**
- 14.2.6.5.7.1** When dry charge batteries have been supplied, electrolyte shall be added to the batteries a minimum of 24 hours prior to the time the engine is to be started and the batteries given a conditioning charge.
- 14.2.6.5.7.2** Engine-driven units shall not show signs of overload or stress.
- 14.2.6.5.7.3** The governor of such units shall be set at the time of the test to properly regulate the engine speed at rated pump speed. (See 11.2.4.1.)
- 14.2.6.5.7.4** Engines equipped with a variable speed control shall have the variable speed control device nonfunctioning when the governor field adjustment in 11.2.4.1 is set and secured.
- 14.2.6.5.8 Steam Turbine-Driven Units.** The steam turbine shall maintain its speed within the limits specified in 13.2.2.
- 14.2.6.5.9 Right Angle Gear Drive Units.** The gear drive assembly shall operate without excessive objectionable noise, vibration, or heating.
- 14.2.6.6 Load Start Test.** The fire pump unit shall be started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load.
- 14.2.6.7* Phase Reversal Test.** For electric motors, a test shall be performed to ensure that there is not a phase reversal condition in either the normal power supply configuration or from the alternate power supply (where provided).
- 14.2.7 Controller Acceptance Test for Electric and Diesel Driven Units.**
- 14.2.7.1*** Fire pump controllers shall be tested in accordance with the manufacturer's recommended test procedure.
- 14.2.7.2** As a minimum, no fewer than six automatic and six manual operations shall be performed during the acceptance test.
- 14.2.7.3** An electric-driven fire pump shall be operated for a period of at least 5 minutes at full speed during each of the operations required in 14.2.7.2.
- 14.2.7.4** An engine-driven fire pump shall not be required to run for 5 minutes at full speed between successive starts until the

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cumulative cranking time of successive starts reaches 45 seconds.

14.2.7.5 The automatic operation sequence of the controller shall start the pump from all provided starting features.

14.2.7.6 This sequence shall include pressure switches or remote starting signals.

14.2.7.7 Tests of engine-driven controllers shall be divided between both sets of batteries.

14.2.7.8 The selection, size, and setting of all overcurrent protective devices, including fire pump controller circuit breaker, shall be confirmed to be in accordance with this standard.

14.2.7.9 The fire pump shall be started once from each power source and run for a minimum of 5 minutes.

CAUTION: Manual emergency operation shall be accomplished by manual actuation of the emergency handle to the fully latched position in a continuous motion. The handle shall be latched for the duration of this test run.

14.2.8 Alternate Power Supply.

14.2.8.1 On installations with an alternate source of power and an automatic transfer switch, loss of primary source shall be simulated and transfer shall occur while the pump is operating at peak load.

14.2.8.2 Transfer from normal to alternate source and return from alternate to normal source shall not cause opening of overcurrent protection devices in either line.

14.2.8.3 At least half of the manual and automatic operations of 14.2.7.2 shall be performed with the fire pump connected to the alternate source.

14.2.8.4 If the alternate power source is a generator set required by 9.3.2, installation acceptance shall be in accordance with NFPA 110.

14.2.9 Emergency Governor for Steam Driven Units.

14.2.9.1 Emergency governor valve for steam shall be operated to demonstrate satisfactory performance of the assembly.

14.2.9.2 Hand tripping shall be acceptable.

14.2.10 Simulated Conditions. Both local and remote signals and fire pump alarm conditions shall be simulated to demonstrate satisfactory operation.

14.2.11^a Test Duration. The fire pump or from concentrate pump shall be in operation for not less than 1 hour total time during all of the foregoing tests.

14.2.12^a Electronic Fuel Management (ECM). For engines with electronic fuel management (ECM) control system, a function test of both the primary and the alternate ECM shall be conducted.

14.3^a Record Drawings, Test Reports, Manuals, Special Tools, and Spare Parts.

14.3.1 One set of record drawings shall be provided to the building owner.

14.3.2 One copy of the completed test report shall be provided to the building owner.

14.3.3^a One set of instruction manuals for all major components of the fire pump system shall be supplied by the manufacturer of each major component.

14.3.4 The manual shall contain the following:

- (1) A detailed explanation of the operation of the component
- (2) Instructions for routine maintenance
- (3) Detailed instructions concerning repairs
- (4) Parts list and parts identification
- (5) Schematic electrical drawings of controller, transfer switch, and fire pump control panels
- (6)^a List of recommended spare parts and lubricants

14.3.5 Any special tools and testing devices required for routine maintenance shall be available for inspection by the authority having jurisdiction at the time of the field acceptance test.

14.4 Periodic Inspection, Testing, and Maintenance. Fire pumps shall be inspected, tested, and maintained in accordance with NFPA 25.

14.5 Component Replacement.

14.5.1 Positive Displacement Pumps.

14.5.1.1 Whenever a critical path component in a positive displacement fire pump is replaced, as defined in 11.5.2.5, a field test of the pump shall be performed.

14.5.1.2 If components that do not affect performance are replaced, such as shafts, then only a functional test shall be required to ensure proper installation and assembly.

14.5.1.3 If components that affect performance are replaced, such as rotors, plungers, and so forth, then a retest shall be conducted by the pump manufacturer or designated representative or qualified persons acceptable to the authority having jurisdiction.

14.5.1.3.1 For water mist positive displacement pumping units, the retest shall include the pump unit as a whole.

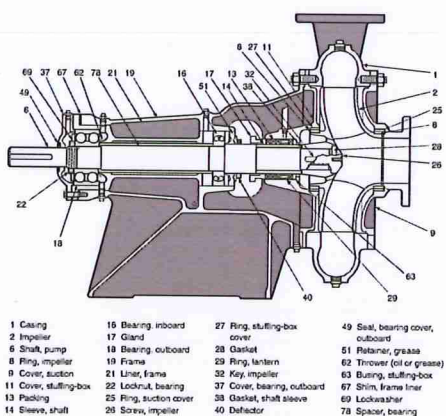
14.5.1.4 Field Retest Results.

14.5.1.4.1 The field retest results shall be compared to the original pump performance as indicated by the fire pump manufacturer's original factory-certified test curve, whenever it is available.

14.5.1.4.2 The field retest results shall meet or exceed the performance characteristics as indicated on the pump nameplate, and the results shall be within the accuracy limits of field testing as stated elsewhere in this standard.

14.5.2 Centrifugal Pumps.

14.5.2.1 Whenever a critical path component in a piece of centrifugal pump equipment is replaced, changed, or modified, a field/on-site retest shall be performed.



1 Casing	16 Bearing inboard	27 Ring, stuffing-box cover	49 Seal, bearing cover, outboard
2 Impeller	17 Gland	28 Gasket	51 Platen, grease
3 Shaft, pump	18 Bearing outboard	29 Ring, lantern	62 Thrower (oil or grease)
4 Ring, impeller	19 Frame	30 Key, impeller	63 Bearing, stuffing-box
5 Cover, suction	20 Liner, frame	31 Key, coupling	67 Shim, frame liner
6 Cover, stuffing-box	21 Locknut, bearing	32 Cover, bearing, outboard	68 Lockwasher
7 Packing	22 Ring, suction cover	33 Gasket, shaft sleeve	70 Spacer, bearing
8 Sleeve, shaft	23 Screw, impeller	40 Deflector	
	24 Overhung impeller		

FIGURE A.6.1.1(b) Overhung Impeller - Separately Coupled Single Stage - Frame Mounted.

After the gasket has set and the foundation bolts have been properly tightened, the unit should be checked for parallel and angular alignment, and, if necessary, corrective measures taken. After the piping of the unit has been connected, the alignment should be checked again.

The direction of drive rotation should be checked to make certain that it matches that of the pump. The corresponding direction of rotation of the pump is indicated by a direction arrow on the pump casing.

The coupling halves can then be reconnected. With the pump properly primed, the unit should be operated under normal operating conditions until temperatures have stabilized. It then should be shut down and immediately checked again for alignment of the coupling. All alignment checks should be made with the coupling halves disconnected and again after they are reconnected.

After the unit has been in operation for about 10 hours, the coupling halves should be given a final check for misalignment caused by pipe or temperature strains. This check should be repeated after the unit has been in operation for about 3 months. If the alignment is correct, both pump and driver should be doweled to the base plate. Dowel location is very important, and the manufacturer's instructions should be followed, especially if the unit is subject to temperature changes.

The unit should be checked periodically for alignment. If the unit does not stay in line after being properly installed, the following are possible causes:

- (1) Settling, subsiding, or springing of the foundation and pipe strains distorting or shifting the machine
- (2) Wearing of the bearings
- (3) Springing of the base plate by heat from an adjacent steam pipe or from a steam turbine
- (4) Shifting of the building structure due to variable loading or other causes
- (5) If the unit and foundation are new, need for the alignment to be slightly readjusted from time to time

A.6.3.2 The listing information contains critical requirements for proper use and installation, including whether the coupling or connecting shaft is listed for use with either an electric motor or diesel engine drivers, or listed for both an electric motor and diesel engine drivers.

A.7.1 Substationary operation of vertical turbine-type pumps is dependent to a large extent upon careful and correct installation of the unit; therefore, it is recommended that this work be done under the direction of a representative of the pump manufacturer.

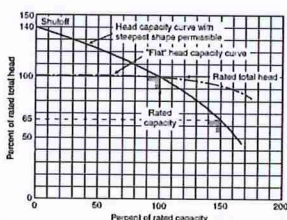
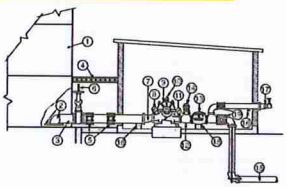


FIGURE A.6.2 Pump Characteristics Curves.



- 1 Aboveground suction tank
- 2 Entrance elbow and square steel
- 3 Suction pipe
- 4 Flanged coupling for strain relief
- 5 OS&Y gate valve (see 4.14.5 and 4.4.14.5)
- 6 Eccentric reducer
- 7 Suction gate
- 8 Horizontal split-case fire pump
- 9 Automatic air release
- 10 Discharge gauge
- 11 Reducing discharge tee
- 12 Discharge check valve
- 13 Relief valve (if required)
- 14 Supply pipe for fire protection system
- 15 Drain valve or ball drop
- 16 Hose valve manifold with hose valves
- 17 Pipe supports
- 18 Indicating gate or indicating butterfly valve
- 19

FIGURE A.6.3.1(a) Horizontal Split-Case Fire Pump Installation with Water Supply Under a Positive Head.

A.7.2.5 Where wells take their supply from consolidated formations such as rock, the specifications for the well should be decided upon by the authority having jurisdiction after consultation with a recognized groundwater consultant in the area.

A.7.2.7 Before the permanent pump is ordered, the water from the well should be analyzed for corrosiveness, including such items as pH, salts such as chlorides, and harmful gases

such as carbon dioxide (CO₂) or hydrogen sulfide (H₂S). If the water is corrosive, the pumps should be constructed of a suitable corrosion-resistant material or covered with special protective coatings in accordance with the manufacturer's recommendations.

A.7.3.1 See Figure A.7.3.1.

A.7.3.2.1 In countries that utilize the metric system, there do not appear to be standardized flow ratings for pump capacities; therefore, a unit metric conversion is utilized.

A.7.3.5.3 Water level detection using the air line method is as follows:

- (1) A satisfactory method of determining the water level involves the use of an air line of small pipe or tubing of known vertical length, a pressure or depth gauge, and an ordinary bicycle or automobile pump installed as shown in Figure A.7.3.5.3. The air line pipe should be of known length and extend beyond the lowest anticipated water level in the well, to ensure more reliable gauge readings, and should be properly installed. An air pressure gauge is used to indicate the pressure in the air line. (See Figure A.7.3.5.3.)
- (2) The air line pipe is lowered into the well, and a pressure gauge is attached. The other connection is connected to a bicycle pump. The air line pipe is lowered into the well, and a pressure gauge is attached. The other connection is connected to a bicycle pump. The air line pipe is lowered into the well, and a pressure gauge is attached. The other connection is connected to a bicycle pump.
- (3) Deducting this pressure converted to feet (meters) (pressure in psi $\times 2.31$ = pressure in feet, and pressure in bar $\times 10.33$ = pressure in meters) from the known length of the air line will give the amount of submergence.

Example: The following calculation will serve to clarify Figure A.7.3.5.3.

Assume a length (L) of 50 ft (15.2 m). The pressure gauge reading before starting the fire pump (P_1) = 10 psi (0.68 bar). Then $A = 10 \times 2.31 = 23.1$ ft (0.68 $\times 10.33 = 7.0$ m). Therefore, the water level in the well before starting the pump would be $B = L - A = 50 \text{ ft} - 23.1 \text{ ft} = 26.9 \text{ ft}$ ($B = L - A = 15.2 \text{ m} - 7 \text{ m} = 8.2 \text{ m}$).

The pressure gauge reading when the pump is running (P_2) = 8 psi (0.55 bar). Then $C = 8 \times 2.31 = 18.5$ ft (0.55 $\times 10.33 = 5.6$ m). Therefore, the water level in the well when the pump is running would be $D = L - C = 50 \text{ ft} - 18.5 \text{ ft} = 31.5 \text{ ft}$ ($D = L - C = 15.2 \text{ m} - 5.6 \text{ m} = 9.6 \text{ m}$).

The draw down can be determined by any of the following methods:

- (1) $D - B = 31.5 \text{ ft} - 26.9 \text{ ft} = 4.6 \text{ ft}$ (9.6 m - 8.2 m = 1.4 m)
- (2) $A - C = 23.1 \text{ ft} - 18.5 \text{ ft} = 4.6 \text{ ft}$ (7.0 m - 5.6 m = 1.4 m)
- (3) $P_1 - P_2 = 10 - 8 = 2 \text{ psi} = 2 \times 2.31 = 4.6 \text{ ft}$ (0.68 - 0.55 = 0.13 bar = 0.13 $\times 10.33 = 1.4$ m)

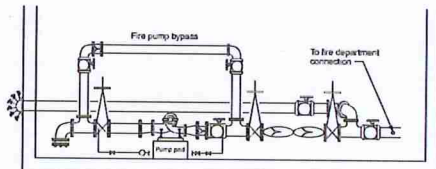


FIGURE A.6.3.1(b) Backflow Preventer Installation.

A.7.4 Several methods of installing a vertical pump can be followed, depending upon the location of the well and facilities available. Since most of the unit is underground, extreme care should be used in assembly and installation, thoroughly checking the work as it progresses. The following simple method is the most common:

- (1) Construct a tripod or portable derrick and use two sets of installing clamps over the open well or pump house. After the derrick is in place, the alignment should be checked carefully with the well or wet pit to avoid any trouble when setting the pump.
- (2) Attach the set of clamps to the suction pipe on which the strainer has already been placed and lower the pipe into the well until the clamps rest on a block beside the well casing or on the pump foundation.
- (3) Attach the clamps to the pump stage assembly, bring the assembly over the well, and install pump stages to the suction pipe, until each piece has been installed in accordance with the manufacturer's instructions.

A.7.6.1.1 The setting of the impeller should be undertaken only by a representative of the manufacturer. Improper setting will cause excessive friction loss due to the rubbing of impellers on pump seals, which results in an increase in power demand. If the impellers are adjusted too high, there will be a loss in capacity, and full capacity is vital for fire pump service. The top shaft nut should be locked or pinned after proper setting.

A.7.6.1.4 Pumping units are checked at the factory for smoothness of performance and should operate satisfactorily on the job. If excessive vibration is present, the following conditions could be causing the trouble:

- (1) Bent pump or column shaft
- (2) Impellers not properly set within the pump bowls
- (3) Pump not hanging freely in the well
- (4) Strain transmitted through the discharge piping

Excessive motor temperature is generally caused either by a maintained low voltage at the electric service or by improper setting of impellers within the pump bowls.

A.8.1 All the requirements in Chapter 4 might not apply to positive displacement pumps.

A.8.1.2 Special attention to the pump inlet piping size and length should be noted.

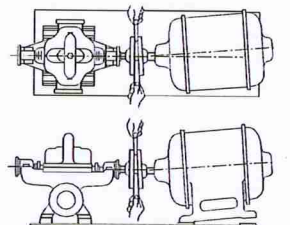


FIGURE A.6.5(a) Checking Angular Alignment. (Courtesy of Hydraulic Institute, www.pump.org.)

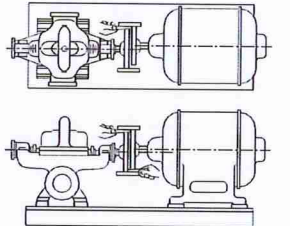


FIGURE A.6.5(b) Checking Parallel Alignment. (Courtesy of Hydraulic Institute, www.pump.org.)

20-86 INSTALLATION OF STATIONARY PUMPS FOR FIRE PROTECTION

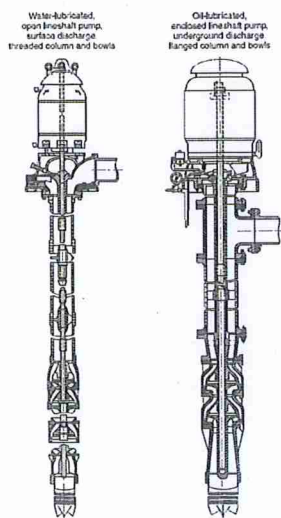
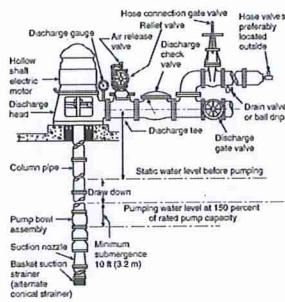


FIGURE A.7.1.1 Water-Lubricated and Oil-Lubricated Shaft Pumps.

A.8.1.2.2 This material describes a simple pump characteristic curve and gives an example of pump selection methods. Characteristic performance curves should be in accordance with III 3.6, *Rating Pump Test*.

Example: An engineer is designing a foam-water fire protection system. It has been determined, after application of appropriate safety factors, that the system needs a foam concentrate pump capable of 45 gpm at the maximum system pressure of 230 psi. Using the performance curve (see Figure A.8.1.2.2) for pump model "XZ2957," this pump is selected for the application. First, find 230 psi on the horizontal axis labeled "differential pressure," then proceed vertically to the flow curve to 45 gpm. It is noted that this particular pump produces 46 gpm at a standard motor speed designated "rpm-2." This pump is an excellent fit for the application. Next, proceed to the power curve for the same speed of rpm-2 at 230 psi and find that it

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Note: The distance between the bottom of the strainer and the bottom of the wet pit should be one-half of the pump bowl diameter but not less than 12 in. (305 mm).

FIGURE A.7.2.1 Vertical Shaft Turbine-Type Pump Installation in a Well.

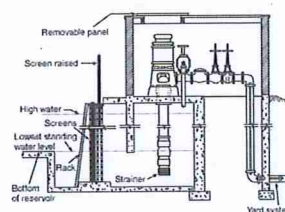


FIGURE A.7.2.2 Vertical Shaft Turbine-Type Pump Installation in a Wet Pit.

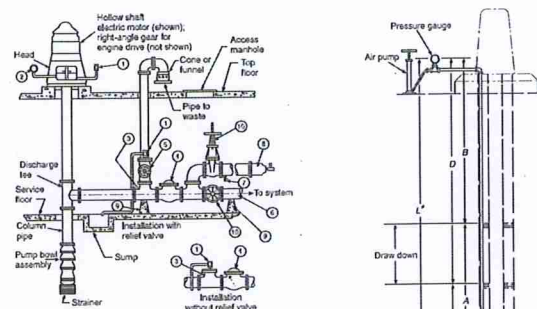
requires 13.1 hp to drive the pump. An electric motor will be used for this application, so a 15 hp motor at rpm-2 is the first available motor rating above this minimum requirement.

A.8.1.5 Positive displacement pumps are tolerance dependent. Corrosion can affect pump performance and function. (See ANSI/HI 2.5, *Standard for Rotary Pumps for Nonlubrication, Design, Application and Operation*.)

A.8.2.2 Specific flow rates should be determined by the applicable NFPA standard. Viscous concentrates and additives have

ANNEX A

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- 1 Automatic air release
- 2 Discharge gauge
- 3 Relieving discharge line
- 4 Discharge check valve
- 5 Relief valve (if required)
- 6 Discharge pipe
- 7 Drain valve or ball drip
- 8 Hose valve manifold with hose valves
- 9 Pipe supports
- 10 Indicating gate or indicating butterfly valve

FIGURE A.7.3.1 Belowground Discharge Arrangement.

Significant pipe friction loss from the supply tank to the pump section.

A.8.2.4 This requirement does not apply to water mist pumps.

A.8.2.5 Generally, pump capacity is calculated by multiplying the maximum water flow by the percentage of concentration desired. To that product is added a 10 percent "over demand" to ensure that adequate pump capacity is available under all conditions.

A.8.2.6 Generally, concentrate pump discharge pressure is required to be added to the maximum water pressure at the injection point plus 25 psi (2 bar).

A.8.3.1 It is not the intent of this standard to prohibit the use of stationary pumps for water mist systems.

A.8.5.2 Positive displacement pumps are capable of quickly exceeding their maximum design discharge pressure if operated against a closed discharge system. Other forms of protective devices (e.g., automatic shutdowns, rupture discs) are considered a part of the pumping system and are generally beyond the scope of the pump manufacturer's supply. These components should be safely designed into and supplied by the system designer or by the user, or both. (See Figure A.8.5.2(a) and Figure A.8.5.2(b) for proposed schematic layout of pump requirements.)

A.8.5.3 Only the tank return line and external valves should be used when the outlet line can be closed for more than a few minutes. Operation of a pump with an integral relief valve and a closed outlet line will cause overheating of the pump and a

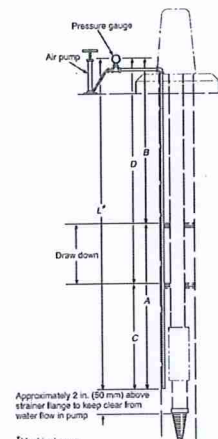


FIGURE A.7.3.3 Air Line Method of Determining Depth of Water Level.

foamy discharge of fluid after the outlet line is reopened. Means of thermal relief should be considered when discharge is piped back to pump section. Overheating of the pump and subsequent damage to the pump can occur quickly if the pump is operated against a closed outlet line and the relief valve discharge is piped back to suction.

A.8.5.4 Backpressure on the discharge side of the pressure relief valve should be considered. (See Figure A.8.5.4 for proposed schematic layout of pump requirements.)

A.8.5.5 Strainer recommended mesh size is based on the internal pump tolerances. (See Figure A.8.5.5 for standard mesh sizes.)

A.8.6.1 Positive displacement pumps are typically driven by electric motors, internal combustion engines, or water motors.

A.8.7 These controllers can incorporate means to permit automatic unloading or pressure relief when starting the pump drive.

A.9.1.4 Where the power supply involves an on-site power production facility, the protection is required for the facility in addition to the wiring and equipment.

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NFPA 25

Standard for the

Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

2017 Edition

This edition of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, was prepared by the Technical Committee on Inspection, Testing, and Maintenance of Water-Based Systems and acted on by NFPA at its June Association Technical Meeting held June 13-16, 2016, in Las Vegas, NV. It was issued by the Standards Council on August 4, 2016, with an effective date of August 24, 2016, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See "Codes & Standards" at www.nfpa.org for more information.

This edition includes the following usability features as aids to the user. Technical changes are indicated by gray shading of the sections. An entire figure caption or table title with gray shading indicates a change to an existing figure or table. New sections, figures, and tables are indicated by a bold, italic "N" in a gray box to the left of the new material. Where one or more sections have been deleted, the deletion is indicated by a bullet (*) between the sections that remain.

This edition of NFPA 25 was approved as an American National Standard on August 24, 2016.

Origin and Development of NFPA 25

The first edition of NFPA 25, in 1992, was a collection of inspection, testing, and maintenance provisions that helped ensure the successful operation of water-based fire protection systems. NFPA 25 was developed as an extension of existing documents such as NFPA 13A, *Recommended Practice for the Inspection, Testing, and Maintenance of Sprinkler Systems*, and NFPA 14A, *Recommended Practice for the Inspection, Testing, and Maintenance of Standpipe and Hose Systems*, which have successfully assisted authorities having jurisdiction and property owners with routine inspections of sprinkler systems and standpipes. These documents have since been withdrawn from the NFPA standards system. NFPA 25 became the main document governing sprinkler systems as well as related systems, including underground piping, fire pumps, storage tanks, water spray systems, and foam-water sprinkler systems.

This document provides instruction on how to conduct inspection, testing, and maintenance activities. It also stipulates how often such activities are required to be completed. Requirements are provided for impairment procedures, modification processes, and system restoration. This type of information, when incorporated into a building maintenance program, enhances the demonstrated favorable experience of all water-based fire protection systems.

The 1995 edition incorporated several improvements that reflected the initial experience with the standard. A new chapter was added that addressed obstructions in pipe as well as appropriate corrective actions.

The 1998 edition refined testing requirements and frequencies and provided additional guidance for preplanned impairment programs. The document scope was expanded to include marine systems.

The 2002 edition continued to refine testing frequencies for waterflow devices and evaluation of the annual fire pump test data. This edition also included additional information regarding evaluation and test methods for microbiologically influenced corrosion (MIC).

In the 2008 edition, a section permitting performance-based testing was added, providing guidance on alternative means for determining testing frequencies based on system/component failure rates. Component replacement testing tables were introduced in this edition to provide

guidance for the appropriate tests to be performed following replacement of system components. Inspection, testing, and maintenance requirements for water mist systems were extracted from NFPA 730 and were inserted into a new chapter. This action consolidated inspection, testing, and maintenance requirements for all water-based fire protection systems into one document.

The 2011 edition further updated testing frequencies based on a growing database of inspection, testing, and maintenance records. In two new annexes, information was provided for classification of needed repairs and hazard evaluation. The 2011 edition also added new definitions differentiating the levels of deficiency for determining the priority of repair.

The 2014 edition of NFPA 25 had many significant changes with many specific to the chapter on fire pumps. The operating test requirements were rewritten to consider a baseline weekly test for all pumps, with a series of exceptions that would allow for a modified testing frequency. New language was added to address confirmation of pressure recordings and a new fuel quality test for diesel-driven pumps.

Definitions were added for the various frequencies of inspection, testing, and maintenance (ITM) tasks to create a "win-win" for completion of the tasks. The concept of internal inspection was modified to an internal assessment concept, in which a performance-based assessment frequency is explicitly addressed. The scope of the Technical Committee on Inspection, Testing, and Water-Based Systems was updated to specifically address water mist systems. The water mist system was modified such that the extract tags from NFPA 750 were removed, since the material in the relevant chapter is now in the jurisdiction of NFPA 25.

A new chapter was added to address NFPA 13D systems that are installed outside of one- and two-family homes. The requirements for inspecting antismoke systems were updated to include the latest information from the Fire Protection Research Foundation testing on standard spray sprinklers. The table providing examples of classifications for deficiencies and impairments was relocated from Annex E to Annex A and attached to the definition of *deficiency*.

For the 2017 edition, new fire pump terms are defined to align with NFPA 20. Criteria have been added to Chapter 4 on automated inspections and testing. Residential sprinkler replacement requirements have been added to address sprinklers that are no longer available. New requirements have been added regarding missing escutcheons or if listed escutcheons are no longer available. ITM tables have been updated throughout the chapters, and new flow test requirements for fire pumps have been added. Chapter 13 has new requirements for the inspection, testing, and maintenance of waterflow alarm devices has separated and added new requirements for the inspection, testing, and maintenance of preaction and deluge valves; has added criteria for air compressors; and now contains all the general pressure gauge criteria. Additionally, there are two new annexes: one on connectivity and data collection and another on collected tagging programs.

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Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates an explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex H. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex H.

Chapter 1 Administration

1.1 Scope. This document establishes the minimum requirements for the periodic inspection, testing, and maintenance of water-based fire protection systems and the actions to undertake when changes in occupancy, use, process, materials, hazard, or water supply that potentially impact the performance of the water-based system are planned or identified.

1.1.1 Coordination with NFPA 72 Testing Requirements. This standard does not address all of the inspection, testing, and maintenance of the electrical components of the automatic fire detection equipment used to activate preaction and deluge systems that are addressed by NFPA 72.

1.1.1.1 The inspection, testing, and maintenance required by this standard and NFPA 72 shall be coordinated so that the system operates as intended.

1.1.1.2* All inspections, testing, and maintenance required by NFPA 72 shall conform to NFPA 72, and the inspection, testing, and maintenance required by this standard shall conform to this standard.

1.1.2 Types of Systems.

1.1.2.1 The types of systems addressed by this standard include, but are not limited to, sprinkler, standpipe and hose, fixed water spray, private fire hydrants, water mist, and foam water.

1.1.2.2 Water supplies that are part of these systems, such as private fire service mains and appurtenances, fire pumps and water storage tanks, and valves that control system flow, are also included in this standard.

1.1.3* This standard addresses the operating condition of fire protection systems as well as impairment handling and reporting and applies to fire protection systems that have been properly installed in accordance with generally accepted practice.

1.1.3.1* This standard does not require the inspector to verify the adequacy of the design of the system.

1.1.4* Corrective action needed to ensure that a system operates in a satisfactory manner shall be in accordance with this standard unless this standard specifically refers to an appropriate installation standard.

1.1.5 Unless required by Chapter 16, this standard shall not apply to sprinkler systems designed, installed, and maintained in accordance with NFPA 13D.

1.2* Purpose.

1.2.1 The purpose of this document is to provide requirements that ensure a reasonable degree of protection for life and property from fire through minimum inspection, testing, and maintenance methods for water-based fire protection systems.

1.2.2 In those cases where it is determined that an existing situation involves a distinct hazard to life or property, the authority having jurisdiction shall be permitted to require inspection, testing, and maintenance methods in excess of those required by this standard.

1.3* Application.

1.3.1* It is not the intent of this standard to limit or restrict the use of other inspection, testing, or maintenance programs that provide an equivalent level of system integrity and performance to that detailed in this standard.

1.3.2 The authority having jurisdiction shall be consulted and approval obtained for such alternative programs.

1.4* Units. Metric units of measurement in this standard are in accordance with the International System of Units (SI).

1.4.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated shall be regarded as the requirement. A given equivalent value shall be considered to be approximate.

Chapter 8: Fire Pumps

8.1* General.

8.1.1 Minimum Requirements.

8.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of fire pump assemblies.

8.1.1.2* The minimum frequency of inspection, testing, and maintenance shall be in accordance with the manufacturer's recommendations and Table 8.1.1.2.

8.1.1.2.1* Shaft movement or end play shall be checked annually with the pump operating.

8.1.1.2.2 Electrical connections shall be checked annually and repaired as necessary.

8.1.1.2.3 Pump and motor bearings and couplings shall be greased annually or as required.

8.1.1.2.4 Printed circuit boards (PCBs) shall be checked annually for corrosion.

8.1.1.2.5 Cable and/or wire insulation shall be checked annually for cracking.

8.1.1.2.6 Plumbing parts, both inside and outside of electrical panels, shall be checked annually for any leaks.

8.1.1.2.7 Fuel tanks, fuel switches, and supervisory signals for interstitial space shall be checked quarterly for liquid intrusion.

8.1.1.2.8 Supervisory signal circuitry shall be checked annually for high cooling water temperature.

8.1.1.2.9 Fuel tanks shall be checked annually for water and foreign materials.

8.1.1.2.10 Fuel tank vents and overflow piping shall be checked annually for any obstructions.

8.1.1.2.11 All flexible hoses and connections shall be checked annually for cracks and leaks.

8.1.1.2.12 Engine crankcase breathers shall be checked quarterly.

8.1.1.2.13 Exhaust systems, drain condensate traps, and silencers shall be checked annually.

8.1.1.2.14 Back pressure on the engine turbo shall be measured annually.

8.1.1.2.15 Batteries shall be checked annually as follows:

- (1) Checking the specific gravity, state of charge, and charger rates of the batteries.
- (2) Cleaning the terminals of any corrosion.
- (3) Ensuring that the cranking voltage exceeds 9 V on a 12 V system or 18 V on a 24 V system.
- (4) Ensuring that only distilled water is used in batteries.

8.1.1.2.16 All controls and power wiring connections shall be checked annually and repaired as necessary.

8.1.1.2.17 Lubricating oil in engines shall be changed every 50 hours of operation or annually.

8.1.1.2.18 Lubricating oil filters shall be changed every 50 hours of operation or annually.

8.1.1.2.19 The condition of sacrificial anodes shall be checked annually and replaced as necessary.

8.1.1.2.20 Circulating water filters shall be replaced annually.

8.1.1.2.21 The accuracy of pressure gauges and sensors shall be inspected annually and replaced or recalibrated when more than 5 percent out of calibration.

8.1.2 Common Components and Valves. Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

8.1.3 Obstruction Investigations. The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

8.1.4* Auxiliary Equipment. The pump assembly auxiliary equipment shall include the following:

- (1) Pump accessories as follows:
 - (a) Pump shaft coupling
 - (b) Automatic air release valve
 - (c) Pressure gauges
 - (d) Circulation relief valve (not used in conjunction with diesel engine drive with heat exchanger)
- (2) Pump test device(s)
- (3) Pump relief valve and piping (where maximum pump discharge pressure exceeds the rating of the system components or the driver is of variable speed)
- (4) Alarm sensors and indicators
- (5) Right-angle gear sets (for engine-driven vertical shaft turbine pumps)
- (6) Pressure maintenance (jockey) pump and accessories

8.1.5 Water Supply to Pump Section.

8.1.5.1 The suction supply for the fire pump shall provide the required flow at a gauge pressure of 0 psi (0 bar) or higher at the pump suction flange to meet the system demand.

8.1.5.2 Those installations for which NFPA 20 permitted negative suction gauge pressures at the time of pump installation, where the system demand will cause the pump to draw water supply, shall be considered to be in compliance with 8.1.5.

8.1.6 Energy Source. The energy sources for the pump driver shall supply the necessary brake horsepower of the driver so that the pump meets system demand.

8.1.7 Drive. The pump driver shall not overload beyond its rating (including any service factor allowance) when delivering the necessary brake horsepower.

8.1.8* Controller. Automatic and manual controllers for applying the energy source to the driver shall be capable of providing this operation for the type of pump used.

8.1.9 Impairments. The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

8.2 Inspection.

8.2.1 The purpose of inspection shall be to verify that the pump assembly appears to be in operating condition and is free from physical damage.

FIRE PUMPS

25-29

Table 8.3.1.2 Summary of Fire Pump Inspection, Testing, and Maintenance

Item	Frequency	Reference
Inspection		
Alignment	Annually	8.3.6.4
Cable/wire insulation	Annually	8.1.1.2.5
Diesel pump system	Weekly	8.2.2(1)
Electric pump system	Weekly	8.2.2(3)
Engine crankcase breather	Annually	8.1.1.2.12
Exhaust system and drain condensate trap	Annually	8.1.1.2.15
Flexible hoses and connections	Annually	8.1.1.2.11
Fuel tank vents and overflow	Annually	8.1.1.2.10
Plumbing parts – inside and outside of panels	Annually	8.1.1.2.6
Printed circuit board corrosion (PCBs)	Annually	8.1.1.2.4
Pump	Weekly	8.2.2(1)
Pump house/room	Annually	8.1.1.2.1
Shaft movement or endplay while running	Weekly	8.2.2(5)
Steam pump system	Annually	8.3.3.7
Suction screens	Annually	8.3.3.7
Test		
Diesel engine-driven fire pump	Weekly	8.3.1.1
Diesel fuel testing	Annually	8.3.4
Electric motor-driven fire pump	Weekly/monthly	8.3.1.2
Fire pump alarm signals	Annually	8.3.3.5
Fuel tank, float switch, and supervisory signal for interstitial space	Quarterly	8.1.1.2.7
Main relief valve	Annually	8.3.3.3
Power transfer switch	Annually	8.3.3.4
Pump operation (no flow)	Annually	8.3.3
Pump performance (flow)	Annually	8.3.3
Supervisory signal for high cooling water temperature	Annually	8.1.1.2.8
Maintenance		
Batteries	Annually	8.1.1.2.15
Circulating water filter	Annually	8.1.1.2.20
Control and power wiring connections	Annually	8.1.1.2.16
Controller	Per manufacturer	8.5
Diesel engine system	Per manufacturer	8.5
Electric motor and power system	Per manufacturer	8.5
Electrical connections	Annually	8.1.1.2.2
Engine lubricating oil	Annually or 50 operating hours	8.1.1.2.17
Engine oil filter	Annually or 50 operating hours	8.1.1.2.18
Fuel tank – check for water and foreign materials	Annually	8.1.1.2.11
Measure back pressure on engine hoses	Annually	8.1.1.2.21
Pressure gauges and sensors	Annually or as required	8.5
Pump and motor bearings and coupling	Annually or as required	8.5
Sacrificial anode	Annually	8.1.1.2.19

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8.2.2* The pertinent visual observations specified in the following checklists shall be performed weekly:

- (1) Pump house conditions are determined as follows:
 - (a) Heat is adequate, not less than 40°F (4°C) for pump rooms with electric motor or diesel engine-driven pumps with engine heaters.
 - (b) Heat is adequate, not less than 70°F (21°C) for pump rooms with diesel engine-driven pumps without engine heaters.
 - (c) Ventilating fans are free to operate.
 - (d) Excessive water does not collect on the floor.
 - (e) Coupling guard is in place.
- (2) Pump system conditions are determined as follows:
 - (a) Pump suction and discharge and bypass valves are fully open.
 - (b) Piping is free of leaks.
 - (c) Suction line pressure gauge reading is within acceptable range.
 - (d) System line pressure gauge reading is within acceptable range.
 - (e) Suction reservoir has the required water level.
 - (f) Wet pit suction screens are unobstructed and in place.
 - (g) Waterflow test valves are in the closed position, the hose retraction valve is closed, and the fire test valve is free of water.
- (3) Electrical system conditions are determined as follows:
 - (a) Controller pilot light (power on) is illuminated.
 - (b) Transfer switch control pilot light is illuminated.
 - (c) Locking switch is closed – standby (emergency) source.
 - (d) Reverse phase alarm pilot light is off, or normal phase rotation pilot light is on.
 - (e) Oil level in vertical motor sight glass is within acceptable range.
 - (f) Power to pressure maintenance (jockey) pump is provided.
- (4) Diesel engine system conditions are determined as follows:
 - (a) Fuel tank is at least two-thirds full.
 - (b) Controller selector switch is in auto position.
 - (c) Batteries' (2) voltage readings are within acceptable range.
 - (d) Batteries' (2) charging current readings are within acceptable range.
 - (e) Batteries' (2) pilot lights are on or battery failure (2) pilot lights are off.
 - (f) All alarm pilot lights are off.
 - (g) Engine running gear motor is reading.
 - (h) Oil level in right angle gear drive is within acceptable range.
 - (i) Crankcase oil level is within acceptable range.
 - (j) Cooling water level is within acceptable range.
 - (k) Electrolyte level in batteries is within acceptable range.
 - (l) Battery terminals are free from corrosion.
 - (m) Water jacket heater is operating.
- (5) Steam system conditions: Steam pressure gauge reading is within acceptable range.

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8.3.1 Testing

8.3.1.1 Frequency

- 8.3.1.1.1* A no-flow test shall be conducted for diesel engine-driven fire pumps on a test frequency in accordance with 8.3.1.1.1 or 8.3.1.1.2.
- 8.3.1.1.2* Except as permitted in 8.3.1.1.2, a weekly test frequency shall be permitted to be established by an approved risk analysis.
- 8.3.1.1.3* A no-flow test shall be conducted for electric motor-driven fire pumps on a test frequency in accordance with 8.3.1.1.3, 8.3.1.2.2, 8.3.1.2.3, or 8.3.1.2.4.
- 8.3.1.2* Except as permitted in 8.3.1.2.2 and 8.3.1.2.3, a weekly test frequency shall be required for the following electric fire pumps:
 - (1) Fire pumps that serve fire protection systems in buildings that are beyond the pumping capacity of the fire department.
 - (2) Fire pumps with limited service controllers.
 - (3) Vertical turbine fire pumps.
 - (4) Fire pumps taking suction from ground level tanks or a water source that does not provide sufficient pressure to be of material value without the pump.

8.3.1.2.2 A monthly test frequency shall be permitted for electric fire pumps not identified in 8.3.1.2.1.

8.3.1.2.3* A monthly test frequency shall be permitted for electric fire pump systems having a redundant fire pump.

8.3.1.2.4* The test frequency shall be permitted to be established by an approved risk analysis.

N 8.3.1.3 An annual flow test shall be conducted in accordance with 8.3.3.

8.3.2 No-Flow Test

8.3.2.1 A no-flow test of fire pump assemblies shall be conducted in accordance with 8.3.2.

N 8.3.2.1.1 Except as permitted in 8.3.2.1.2 and 8.3.2.1.3, a main pressure relief valve (where installed) shall be permitted to weep but not discharge a significant quantity of water.

8.3.2.1.1.1 Except as required in 8.3.2.1.2, the circulation relief valve shall discharge a small flow of water.

8.3.2.1.2 The circulation relief valve shall not operate when the flow through the main pressure relief valve is greater than weeping.

N 8.3.2.1.2.1 For fire pump installations that were installed under a standard (1993 and earlier editions of NFPA 20) that did not prohibit a design that required operation of a pressure relief valve to keep the discharge pressure below the rating of the system components, the pressure relief valve shall be permitted to operate as designed during a no-flow test.

8.3.2.1.2.1* The pressure readings on the discharge and suction gauges shall be recorded, and a pressure difference that is greater than 95 percent of the rated pump pressure shall be investigated and corrected.

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8.3.2.1.2.2* The discharge temperature of the water shall be monitored and the pump shut down if necessary to prevent exposing the pump and/or driver to excessive temperatures.

N 8.3.2.1.3 For positive displacement pumps, the pressure relief valve shall operate during a no-flow test.

8.3.2.1.3.1 Where the pressure relief valve is piped back to suction, the pump circulation relief valve shall not operate.

8.3.2.1.3.2 On electric motor and radiator cooled engine drives, a circulation pressure relief valve located downstream of the main pressure relief valve shall discharge sufficient water to prevent overheating of the pump.

8.3.2.2 The test shall be conducted by starting the pump automatically.

8.3.2.3 The electric pump shall run a minimum of 10 minutes.

8.3.2.4 The diesel pump shall run a minimum of 30 minutes.

8.3.2.5 A valve installed to open as a safety feature shall be permitted to discharge water.

8.3.2.6 An automatic timer that meets 8.3.2.6.1 through 8.3.2.6.3 shall be permitted to be substituted for the starting procedure.

8.3.2.6.1 A solenoid valve drain on the pressure control line shall be the initiating means for a pressure-actuated controller.

8.3.2.6.2 In a pressure-actuated controller, performance of this program timer shall be recorded as a pressure drop indication on the pressure recorder.

8.3.2.6.3 In a non-pressure-actuated controller, the test shall be permitted to be initiated by means other than a solenoid valve.

8.3.2.7 Qualified personnel shall be in attendance whenever the pump is in operation.

8.3.2.7.1* The use of the automatic timer allowed in 8.3.2.6 shall not eliminate the requirement of 8.3.2.7 to have qualified personnel present during the test.

8.3.2.8 The pertinent visual observations or adjustments specified in the following checklists shall be conducted while the pump is idle:

- (1) Record the system suction and discharge pressure readings.
- (2) For pumps that use electronic pressure sensors to control the fire pump operation, record the current pressure and the highest and the lowest pressure shown on the fire pump controller event log.
- (3) If the highest or lowest pressure is outside of the expected range, record all information from the event log that helps identify the abnormality.

8.3.2.9 The pertinent visual observations or adjustments specified in the following checklists shall be conducted while the pump is running:

- (1) Pump system procedure is as follows:
 - (a) Record the pump starting pressure from the pressure switch or pressure transducer.
 - (b) Record the system suction and discharge pressure gauge readings.

- (c) Inspect the pump packing glands for slight discharge.
- (d) Adjust gland nuts if necessary.
- (e) Inspect for unusual noise or vibration.
- (f) Inspect packing boxes, bearings, or pump casing for overheating.
- (g) Record pressure switch or pressure transducer reading and compare to the pump discharge gauge.
- (h) For pumps that use electronic pressure sensors to control the fire pump operation, record the current pressure and the highest and the lowest pressure shown on the fire pump controller event log.
- (i) For electric motor and radiator cooled diesel pumps, check the circulation relief valve for operation to discharge water.

(2) Electrical system procedure is as follows:

- (a) Observe the time for motor to accelerate to full speed.
 - (b) Record the time controller is on first step (for reduced voltage or reduced current starting).
 - (c) Record the time pump runs after starting (for automatic stop controller).
- (3) Diesel engine system procedure is as follows:
- (a) Observe the time for engine to crank.
 - (b) Observe the time for engine to reach running speed.
 - (c) Observe the engine oil pressure gauge, speed indicator, water, and oil temperature indicators periodically while engine is running.
 - (d) Record any abnormalities.
 - (e) Inspect the heat exchanger for cooling waterflow.

(4) Steam system procedure is as follows:

- (a) Record the steam pressure gauge reading.
- (b) Observe the time for turbine to reach running speed.

8.3.3 Annual Flow Testing

8.3.3.1* An annual test of each pump assembly shall be conducted by qualified personnel under no-flow (thru), rated flow, and 150 percent of the pump rated capacity flow of the fire pump by controlling the quantity of water discharged through approved test devices.

8.3.3.1.1 If available suction supplies do not allow flowing of 150 percent of the rated pump capacity, the fire pump shall be tested to the maximum allowable discharge.

N 8.3.3.2 Test Equipment

8.3.3.2.1 Voltage and amperage readings on fire pump controllers that meet the following criteria shall be permitted in lieu of calibrated voltage and/or amperage meters:

- (1) The fire pump controller shall have been factory calibrated and adjusted to ±3 percent.
- (2) The voltage reading shall be within 5 percent of the rated voltage.

8.3.3.2.2 Except as permitted in 8.3.3.2.1, calibrated test equipment shall be provided to determine net pump pressures, rate of flow through the pump, valve and amperage, and speed.

8.3.3.2.2.1 Calibrated gauges, transducers, and other devices used for measurement during the test shall be used and bear a label with the latest date of calibration.

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8.3.3.2.2.2 Gauges, transducers, and other devices, with the exception of flow meters, used for measurement during the test shall be calibrated to a minimum of annually to an accuracy level of 1 percent.

8.3.3.2.2.3 Flow meters shall be calibrated annually to an accuracy level of 5 percent.

8.3.3.3 Discharge and sensing orifices that can be visually observed without disassembling equipment, piping, or valves shall be visually inspected and be free of damage and obstructions that could affect the accuracy of the measurement.

8.3.3.4 The sensing/measuring elements in a flow meter shall be calibrated in accordance with 8.3.3.2.

8.3.3.5 Discharge orifices shall be listed or constructed to a recognized standard with a known discharge coefficient.

8.3.3.6 The annual test shall be conducted as follows:

- (1) The arrangement described in 8.3.3.6.1 or 8.3.3.6.2 shall be used at a minimum of every third year.
- (2)* The arrangement described in 8.3.3.6.3 shall be permitted to be used two out of every three years.

8.3.3.6.1 Use of Pump Discharge via Hose Streams

8.3.3.6.1.1 Pump suction and discharge pressures and the flow measurements of each hose stream shall determine the total pump output.

8.3.3.6.1.2* Care shall be taken to minimize any water damage caused by the high volume of water discharging during the test.

8.3.3.6.2 Use of Pump Discharge via Bypass Flowmeter to Drain or Suction Reservoir. Pump suction and discharge pressures and the flowmeter measurements shall determine the total pump output.

8.3.3.6.3 Use of Pump Discharge via Bypass Flowmeter to Pump Suction (Closed-Loop Metering).

8.3.3.6.3.1 Pump suction and discharge pressures and the flowmeter measurements shall determine the total pump output.

8.3.3.6.3.2 When testing includes recirculating water back to the fire pump suction, the temperature of the recirculating water shall be monitored to verify that it remains below temperatures that could result in equipment damage as defined by the pump and engine manufacturer.

N 8.3.3.6.3.3 If the test results are not consistent with the previous annual test, the test shall be repeated using the test arrangement described in 8.3.3.6.3.1.

8.3.3.6.3.4 If testing in accordance with 8.3.3.6.3.1 is not possible, a flowmeter calibration shall be performed and the test shall be repeated.

8.3.3.7 The pertinent visual observations, measurements, and adjustments specified in the following checklist shall be conducted annually while the pump is running and flowing water under the specified output condition:

- (1) At no-flow condition (thru), the procedure is as follows:
 - (a) Inspect the circulation relief valve for operation to discharge water.
 - (b) Inspect the pressure relief valve (if installed) for proper operation.

(2) At each flow condition, the procedure is as follows:

- (a) Record the electric motor voltage and current (all lines).
- (b) Record the pump speed in rpm.
- (c) Record the simultaneous (approximately) readings of pump suction and discharge pressures and pump discharge flow.
- (3)* For electric motor-driven pumps, do not shut down the pump until it has run for 10 minutes.
- (4) For diesel motor-driven pumps, do not shut down the pump until it has run for 30 minutes.

8.3.3.8* For installations having a pressure relief valve, the operation of the relief valve shall be closely observed during each flow condition to determine whether the pump discharge pressure exceeds the normal operating pressure of the system components.

8.3.3.8.1* The pressure relief valve shall also be observed during each flow condition to determine whether the pressure relief valve closes at the proper pressure.

8.3.3.8.2 The pressure relief valve shall be closed during flow conditions if necessary to achieve minimum rated characteristics for the pump and reset to normal position at the conclusion of the pump test.

8.3.3.8.2.1 When it is necessary to close the relief valve to achieve minimum rated characteristics for the pump, the pump discharge control valve shall be closed if the pump churn pressure exceeds the system rated pressure.

8.3.3.8.3 When pressure relief valves are piped back to the fire pump suction, the temperature of the recirculating water shall be monitored to verify that it remains below temperatures that could result in equipment damage as defined by the pump and engine manufacturer.

8.3.3.9 For installations having an automatic transfer switch, the following test shall be performed to ensure that the overcurrent protective devices (i.e., fuses or circuit breakers) do not open:

- (1) Simulate a power failure condition while the pump is operating at peak load.
- (2) Verify that the transfer switch transfers power to the alternate power source.
- (3) While the pump is operating at peak load and alternate power, record the voltage, amperage, rpm, suction pressure, discharge pressure, and flow rate and include in the pump test results.
- (4) Verify that the pump continues to perform at peak, base power load on the alternate power source for a minimum of 2 minutes.
- (5) Remove the power failure condition and verify that, after a time delay, the pump is reconnected to the normal power source.

8.3.3.10* Alarm conditions shall be simulated by activating alarm circuits at alarm sensor locations, and all such local or remote alarm indicating devices (visual and audible) shall be observed for operation.

N 8.3.3.10.1 Alarm conditions that require the controller to be opened in order to create or simulate the condition shall be tested by qualified personnel wearing appropriate protective equipment.

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8.3.3.11* Safety. Section 4.9 shall be followed for safety requirements while working near electric motor-driven fire pumps.

8.3.3.12* Suction Screens. After the waterflow portion of the annual test or fire protection system activations, the suction screens shall be inspected and cleared of any debris or obstructions.

8.3.3.13* Where engines utilize electronic fuel management control systems, the backup electronic control module (ECM) and the primary and redundant sensors for the ECM shall be tested annually.

8.3.4 Diesel Fuel Testing and Maintenance.

8.3.4.1 Diesel fuel shall be tested for degradation no less than annually.

8.3.4.1.1* Fuel degradation testing shall comply with ASTM D975, *Standard Specification for Diesel Fuel Oils*, or ASTM D6751, *Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels*, as approved by the engine manufacturer, using ASTM D7162, *Standard Test Method for Oxidation Stability of Biodiesel (B100) and Blends of Biodiesel with Middle Distillate Petroleum Fuel (Marine Method)*.

8.3.4.2* If diesel fuel is found to be deficient in the testing required in 8.3.4.1.1, the fuel shall be reconditioned or replaced; the supply tank shall be cleaned internally, and the engine fuel filter(s) shall be changed.

8.3.4.2.1 After the restoration of the fuel and tank in 8.3.4.2, the fuel shall be retested every 6 months until experience indicates the fuel can be stored for a minimum of 1 year without degradation beyond that allowed in 8.3.4.1.1.

8.3.4.3 When provided, active fuel maintenance systems shall be listed for fire pump service.

8.3.4.3.1 Maintenance of active fuel maintenance systems shall be in accordance with the manufacturer's recommendations.

8.3.4.3.2 Maintenance of active fuel maintenance systems shall be performed at a minimum annual frequency for any portion of the system that the manufacturer does not provide a recommended maintenance frequency.

8.3.4.3.3 Where utilized, fuel additives shall be used and maintained in accordance with the active fuel maintenance system manufacturer's recommendations.

8.3.5 Positive Displacement Pumps. [2011.2.6.4.3.1]

8.3.5.1 Except as provided in 8.3.5.1 through 8.3.5.7, positive displacement pumps shall be tested in accordance with 8.3.1 through 8.3.3.

8.3.5.2 The pump flow for positive displacement pumps shall be tested and determined to meet the specified rated performance criteria where only one performance point is required to establish positive displacement pump acceptability. [2011.2.6.4.3.1]

8.3.5.3 The pump flow test for positive displacement pumps shall be accomplished using a flowmeter or orifice plate installed in a test loop back to the supply tank, to the inlet side of a positive displacement water pump, or to drain. [2011.2.6.4.3.2]

8.3.5.4 The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer's flow performance data. [2011.2.6.4.3.3]

8.3.5.5 If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side of the orifice plate shall be made available to the authority having jurisdiction. [2011.2.6.4.3.4]

8.3.5.6 Flow rates shall be as specified while operating at the system design pressure. Tests shall be performed in accordance with NFPA 20, *Fire Pump Tests*. [2011.2.6.4.3.5]

8.3.5.7 Positive displacement pumps intended to pump liquids other than water shall be permitted to be tested with water; however, the pump performance will be affected, and manufacturer's calculations shall be provided showing the difference in viscosity between water and the system liquid. [2011.2.6.4.3.6]

8.3.6 Other Tests.

8.3.6.1* Engine generator sets supplying emergency or standby power to fire pump assemblies shall be tested routinely in accordance with NFPA 110.

8.3.6.2 Automatic transfer switches shall be tested routinely and exercised in accordance with NFPA 110.

8.3.6.3 Tests of appropriate environmental pump room space conditions (e.g., heating, ventilation, filtration) shall be made to ensure proper manual or automatic operation of the associated equipment.

8.3.6.4* Parallel and angular alignment of the pump and driver shall be inspected during the annual test, and any misalignment shall be corrected.

8.3.7 Test Results and Evaluation.

8.3.7.1* Data Interpretation.

8.3.7.1.1 The interpretation of the flow test performance relative to the manufacturer's performance shall be the basis for determining performance of the pump assembly.

8.3.7.1.2 Qualified individuals shall interpret the test results.

8.3.7.1.3 Where applicable, speed and velocity pressure adjustments shall be applied to the test pressure and flow data obtained to determine compliance with 8.3.7.2.3(2).

8.3.7.2 Evaluation of Fire Pump Test Results.

8.3.7.2.1 The fire pump test results shall be evaluated in accordance with 8.3.7.2.2 through 8.3.7.2.3.

8.3.7.2.2 Increasing the engine speed beyond the rated speed of the pump shall not be permitted as a method for meeting the rated pump performance.

8.3.7.2.3 The fire pump test results shall be considered acceptable if both of the following conditions are satisfied:

- (1) Fire pump can supply the full system demand as provided by the owner.
- (2)* Fire pump test results are no less than 95 percent of the flow rates and pressures at each point for either a or b:
 - (a) Original unadjusted field test curve
 - (b) Fire pump nameplate

8.3.7.2.4* Upon failure to meet the criteria in 8.3.7.2.3, the following actions shall occur:

- (1) The owner shall be notified.
- (2) An investigation shall be conducted to reveal the cause of the degraded performance.
- (3) The deficiency shall be corrected.

8.3.7.2.5 For electric motor-driven fire pumps operating at constant speed, the current at each flow rate test point and at each phase shall not exceed the product of the electric motor service factor and the full-load amperage rating of the motor.

8.3.7.2.6 Where the current at each flow rate test point and at each phase exceeds the product of the electric motor service factor and the full-load amperage rating of the motor, the source of the problem shall be identified and corrected.

8.3.7.2.7 For electric motor-driven fire pumps operating at varying voltage, the product of the test voltage and the current at each test point and on each phase shall not exceed the product of the voltage and the full-load current times the motor service factor; the source of the problem shall be identified and corrected.

8.3.7.2.8 Where the product of the test voltage and the current at each test point and on each phase exceeds the product of the voltage and the full-load current times the motor service factor, the source of the problem shall be identified and corrected.

8.3.7.2.9 Voltage readings at the motor within 5 percent below or 10 percent above the rated (i.e., nameplate) voltage shall be considered acceptable.

8.3.7.2.10 A written or electronic record of the results of the investigation and the corrective action shall be prepared and maintained by the owner.

8.4 Reports.

8.4.1* A complete written report of the fire pump test results shall be prepared for and retained by the owner.

8.4.1.1 As a minimum, the report shall contain the following information:

- (1) All raw data necessary for a complete evaluation of the fire pump performance, including suction and discharge pressures, voltage and amperage readings, and pump speed at each flow rate tested.

(2) The fire protection system demand as furnished by the owner.

(3) Pump performance, whether satisfactory or unsatisfactory.

(4) Deficiencies noted during the testing and identified during analysis, with recommendations to address deficiencies as appropriate.

(5) Manufacturer's performance data, actual performance, and the available pump discharge curves required by this standard.

(6) Time delay intervals associated with the pump's starting, stopping, and energy source transfer.

(7) Where applicable, comparison with previous test results.

8.5 Maintenance.

8.5.1* A preventive maintenance program shall be established on all components of the pump assembly in accordance with the manufacturer's recommendations or an approved alternate maintenance plan.

8.5.2 Records shall be maintained on all work performed on the pump, driver, controller, and auxiliary equipment.

8.5.3 The preventive maintenance program shall be initiated immediately after the pump assembly has passed acceptance tests.

8.6 Component Replacement Testing Requirements.

8.6.1 Whenever a component in a fire pump is adjusted, repaired, rebuilt, or replaced, the tests required to restore the system to service shall be performed in accordance with Table 8.6.1.

8.6.2 NFPA 20 shall be consulted for the minimum requirements for design, installation, and acceptance testing.

8.6.3 Replacement parts shall be provided that will maintain the listing for the fire pump component assembly whenever possible.

8.6.3.1 If the part is no longer available from the original equipment manufacturer, then an approved like part shall be permitted to be used.

Table 8.6.1 Summary of Component Action Requirements

Component	Adjust	Repair	Rebuild	Replace	Test Criteria
Fire Pump System					
Impeller/pump assembly				X	Perform acceptance test in accordance with NFPA 20
Impeller/rotating assembly		X		X	Perform acceptance test in accordance with NFPA 20
Casing		X		X	Perform acceptance test in accordance with NFPA 20
Bearings				X	with alignment inspection
Sleeves				X	Perform annual test in accordance with 8.3.3
Wear rings				X	Perform annual test in accordance with 8.3.3
Main shaft				X	Perform annual test in accordance with 8.3.3
Packing	X	X		X	Perform test in accordance with 8.3.2
Mechanical Transmission					
Gear right angle drives		X	X	X	Perform acceptance test in accordance with NFPA 20
Drive coupling	X	X	X	X	Perform test in accordance with 8.3.3 with alignment inspection
Electrical System/Controller					
Entire controller				X	Perform acceptance test in accordance with NFPA 20
Electronic component or module that can prevent the controller from starting or running			X	X	Perform acceptance test in accordance with NFPA 20
Electronic component or module that will not prevent the controller from starting or running			X	X	Perform weekly test in accordance with NFPA 25
Plumbing part isolating switch				X	Perform weekly test in accordance with NFPA 25
Circuit breaker	X			X	Perform test in accordance with 8.3.2 and exercise six times
Circuit breaker				X	Perform six momentary starts in accordance with NFPA 20
Electrical connections	X			X	Test in accordance with 8.3.3, including six starts at peak load and operate pump for a minimum of one hour
Main contacts		X		X	Perform test in accordance with 8.3.2
Power monitor				X	Perform test in accordance with 8.3.3 with six starts
Start relay	X			X	Perform six operations of the circuit breaker/ isolation switch disconnect (cycle the power on/off)
Pressure switch		X		X	Perform test in accordance with 8.3.2 with six starts
Pressure transducer	X			X	Perform test in accordance with 8.3.2 and exercise six times automatically
Manual start or stop switch		X		X	Perform six automatic no-load starts
Transfer switch — load carrying parts		X	X	X	Perform six operations under load
Transfer switch — no-load parts		X	X	X	Test in accordance with 8.3.3, including six starts at peak horsepower load, operate pump for a minimum of one hour, and transfer from normal power in emergency power and back one time
Electric Motor Driver					
Electric motor	X	X		X	Perform six no-load operations of transfer of power
Motor bearings				X	Perform acceptance test in accordance with 8.3.3, including alignment tests
Incoming power conductors				X	Perform annual test in accordance with 8.3.3
Diesel Engine Driver					
Entire engine			X	X	Test in accordance with 8.3.3 and operate pump for a minimum of one hour, including six starts at peak load
Fuel transfer pump	X		X	X	Perform acceptance test in accordance with NFPA 20
					Perform test in accordance with 8.3.2

(continues)

Table 8.6.1 Continued

Component	Adjust	Repair	Rebuild	Replace	Test Criteria
Fuel Injector Pump or ECM	X			X	Perform test in accordance with 8.3.3
Fuel system filter		X		X	Perform test in accordance with 8.3.2
Combustion air intake system		X		X	Perform test in accordance with 8.3.2
Fuel tank		X		X	Perform test in accordance with 8.3.2
Cooling system			X	X	Perform test in accordance with 8.3.3
Batteries		X		X	Perform start/stop sequence in accordance with NFPA 25
Battery charger		X		X	Perform test in accordance with 8.3.2
Electric system		X		X	Perform test in accordance with 8.3.2
Lubrication filter/oil service		X		X	Perform test in accordance with 8.3.2
Steam Turbines					
Steam turbine		X		X	Perform acceptance test in accordance with NFPA 20
Steam regulator or source upgrade		X		X	Perform acceptance test in accordance with NFPA 20
Positive Displacement Pumps					
Entire pump				X	Perform acceptance test in accordance with NFPA 20
Rotors				X	Perform annual test in accordance with 8.3.3
Plungers				X	Perform annual test in accordance with 8.3.3
Shaft			X	X	Perform annual test in accordance with 8.3.3
Driver		X		X	Perform acceptance test in accordance with NFPA 20
Bearings				X	Perform annual test in accordance with 8.3.3
Seals				X	Perform test in accordance with 8.3.2
Pump House and Miscellaneous Components					
Baseplate		X			Perform test in accordance with 8.3.2 with alignment inspection
Baseplate				X	Perform test in accordance with 8.3.3 with alignment inspection
Foundation		X	X	X	Perform test in accordance with 8.3.2 with alignment inspection
Suction/discharge pipe		X		X	Perform visual inspection in accordance with 8.2.2
Suction/discharge fittings		X		X	Perform visual inspection in accordance with 8.2.2
Suction/discharge valves		X	X	X	Perform operational test in accordance with 13.3.3.1

เอกสารแนบที่ 2.31

ฝึกซ้อมสถานการณ์ฉุกเฉิน