

เอกสารแนบที่ 50

ตัวอย่างการทดสอบ ตรวจสอบ และบำรุงรักษาระบบดับเพลิง

รายงานการทดสอบประสิทธิภาพของ
เครื่องสูบน้ำดับเพลิง ประจำปี 2567
(Fire Pump Performance Test Report 2024)

บริษัท ใดกิ อลูมิเนียม อินดัสทรี
(ประเทศไทย) จำกัด
(โรงงานระยอง)

เดือน มิถุนายน 2567



บริษัท ไฟโรเทค เอ็นจิเนียริง จำกัด
19/29-30 หมู่ 13 ซ.นวมินทร์ คลองกุ่ม บางกะปิ กทม. 10240
โทร: 0-2733-4614, 0-2733-4615, 0-2733-4616 แฟกซ์: 0-2733-4617

สารบัญ

- รายงานการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง
(Fire Pump Performance Test Report)
- ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง
- เอกสารของผู้ควบคุมงานการทดสอบ
- รายละเอียดของเครื่องมือวัดที่เกี่ยวข้องกับการทดสอบ
- รายละเอียดข้อมูล NFPA. 20 & NFPA.25 (ที่เกี่ยวข้อง)

1. รายงานการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง
(Fire Pump Performance Test Report)

ANNUAL FLOW TEST REPORT
FOR THE MONTH OF JUNE 2024
ELECTRIC MOTOR FIRE PUMP

| | | | | | |
|--|--|---------------------------|--|--|--|
| Project Name : DAIKI ALUMINIUM (Rayong plant) | | Service Date : 14/06/2024 | | Time : 8:00 | |
| Job no. : P0524096-A | | Contract no. : - | | Technician : Mr.Apirak Thavonasin | |
| Customer Name : DAIKI ALUMINIUM INDUSTRY (THAILAND) CO.,LTD. | | | | Engineer : | |
| Address : 7/412 Moo 6 T.Mahayangpoom, A.Phuakhaeng, Rayong 21140 | | | | Remarks : | |
| Tel. : (096) 324-4615 | | Fax : | | มีจุดเริ่มต้นทางสิ่งแวดล้อมที่ผู้ควบคุมอยู่ถัดมา | |
| Attention : คุณวิจิตรชน นันทน์ | | Date : 14/06/2024 | | "OFF" | |

| UNIT DATA | | | | | |
|---|--|---|--|--|--|
| PUMP | | MOTOR | | CONTROLLER | |
| Pump Brand : EBARA PUMP | | Brand : BROOK CROMPTON | | Control Brand : | |
| Model : 106x80 FSJA | | Model : T-DE200LB-2 PTC 1R | | Model : | |
| S/N : 630722 | | S/N : K71676R | | S/N : | |
| <input type="checkbox"/> UL LISTED <input type="checkbox"/> FM APPROVED | | <input type="checkbox"/> UL LISTED <input type="checkbox"/> FM APPROVED | | <input type="checkbox"/> UL LISTED <input type="checkbox"/> FM APPROVED | |
| Pump Speed : rpm. | | Speed : 2,955 rpm. | | Power Supply : 380 V., 3 Phase, 50 Hz. | |
| Flow Rate : gpm. | | Type : - Horse Power : 37 kw. | | Type start : <input type="checkbox"/> D.O.L <input checked="" type="checkbox"/> Star-Delta | |
| TDH : psi. | | Power Supply : 380 V., 3 Phase, 50 Hz. | | <input type="checkbox"/> Auto transformer | |
| Max. Working Pressure : psi. | | Full Load : A. | | | |

| PRE - START UP DATA | | | | |
|---------------------|--------------------------------|--|-------------------------------------|------------------------------|
| P U M P | 1. Suction Valve | <input checked="" type="checkbox"/> Passed | <input type="checkbox"/> Not Passed | <input type="checkbox"/> N/A |
| | 2. Discharge 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. Lubrication | <input checked="" type="checkbox"/> Passed | <input type="checkbox"/> Not Passed | <input type="checkbox"/> N/A |
| | 7. Vibration | <input checked="" type="checkbox"/> Passed | <input type="checkbox"/> Not Passed | <input type="checkbox"/> N/A |

| MOTOR TEST | | | | |
|-----------------------|--|--|-------------------------------------|---|
| M O T O R | 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 |
| | 3. Lubrication | <input type="checkbox"/> Passed | <input type="checkbox"/> Not Passed | <input checked="" type="checkbox"/> N/A |
| | 4. Running amperage I= 41.47 A, S= 40.06 A, T= 40.89 A | <input checked="" type="checkbox"/> Passed | <input type="checkbox"/> Not Passed | <input type="checkbox"/> N/A |

Pump Number : ELECTRIC MOTOR FIRE PUMP

Location : Fire 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 | | | 50.800 | | | 101.252 | | | 150.458 | | | 200.414 | | | 250.000 | | | 300.923 | | |
| Suction Pressure (psi.) , Actual Test | 4.5 | | | 3.5 | | | 1 | | | -1.75 | | | -5 | | | -7.5 | | | -12 | | |
| Discharge Pressure (psi.) , Actual Test | 120 | | | 120 | | | 115 | | | 110 | | | 105 | | | 99 | | | 90 | | |
| Net Pressure (psi.) (Discharge Pressure Minus Suction Pressure) | 115.5 | | | 116.5 | | | 114 | | | 111.75 | | | 110 | | | 106.5 | | | 102 | | |
| Pump Speed (rpm.) , Actual Test | 2,990 | | | 2,986 | | | 2,987 | | | 2,984 | | | 2,983 | | | 2,979 | | | 2,976 | | |
| Current (R , S , T) (Amp.) | 29.65 | 28.36 | 28.84 | 32.86 | 31.60 | 31.75 | 36.09 | 34.66 | 35.27 | 39.48 | 37.61 | 37.70 | 41.47 | 40.06 | 40.89 | 44.4 | 43.6 | 43.1 | 48.2 | 46.2 | 46.8 |
| Voltage (RS , ST , RT) (Volt.) | 392.3 | 391.9 | 393.3 | 393.4 | 393.6 | 394.9 | 394.2 | 394.5 | 395.6 | 394.3 | 394.4 | 395.2 | 394.7 | 395.3 | 396.0 | 392.9 | 394.0 | 394.4 | 393.0 | 393.4 | 394.0 |

ELECTRIC MOTOR FIRE PUMP

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 checked="" type="checkbox"/> | Passed | <input type="checkbox"/> | Not Passed | <input type="checkbox"/> N/A |
| N | 3. Power Supply Condition <u>380_V</u> . | <input checked="" type="checkbox"/> | Passed | <input type="checkbox"/> | Not Passed | <input type="checkbox"/> N/A |
| T | 4. Magnetic Contactor Start <input type="checkbox"/> D.O.L <input checked="" type="checkbox"/> Star-Delta | <input checked="" type="checkbox"/> | Passed | <input type="checkbox"/> | Not Passed | <input type="checkbox"/> N/A |
| R | <input type="checkbox"/> Auto transformer | | | | | |
| O | 5. Overload Relay <u>A</u> , set at <u>A</u> | <input type="checkbox"/> | Passed | <input type="checkbox"/> | Not Passed | <input type="checkbox"/> N/A |
| L | 6. Timer Off Relay (Set <u>-</u> mins.) | <input type="checkbox"/> | Passed | <input type="checkbox"/> | Not Passed | <input type="checkbox"/> N/A |
| L | 7. Pressure Switch Test (Start Set <u>psi</u>) | <input type="checkbox"/> | Passed | <input type="checkbox"/> | Not Passed | <input type="checkbox"/> N/A |
| E | (Stop Set <u>psi</u>) Manual Stop | | | | | |
| R | 8. Emergency run mechanical start. | <input type="checkbox"/> | Passed | <input type="checkbox"/> | Not Passed | <input checked="" type="checkbox"/> N/A |

TEST DATA

1. Discharge Pressure 105 psi.
2. Suction Pressure -10 in.Hg.
3. Water Flow Rate 200 gpm.
4. Relief Valve Setting - psi, Pump Speed 2,983 rpm.
5. Voltage (R-S, S-T, R-T) 394.7, 395.3, 396.0 Volt.
6. Running Amperage (R, S, T) 41.47, 40.06, 40.89 Amp.
7. Pressure cut - in - psi.
8. Pressure cut - off - psi, Manual Stop
9. Working Pressure 105 psi.

Remark :

FIRE PUMP PERFORMANCE TESTS (Annual Flow Test, Year 2024)

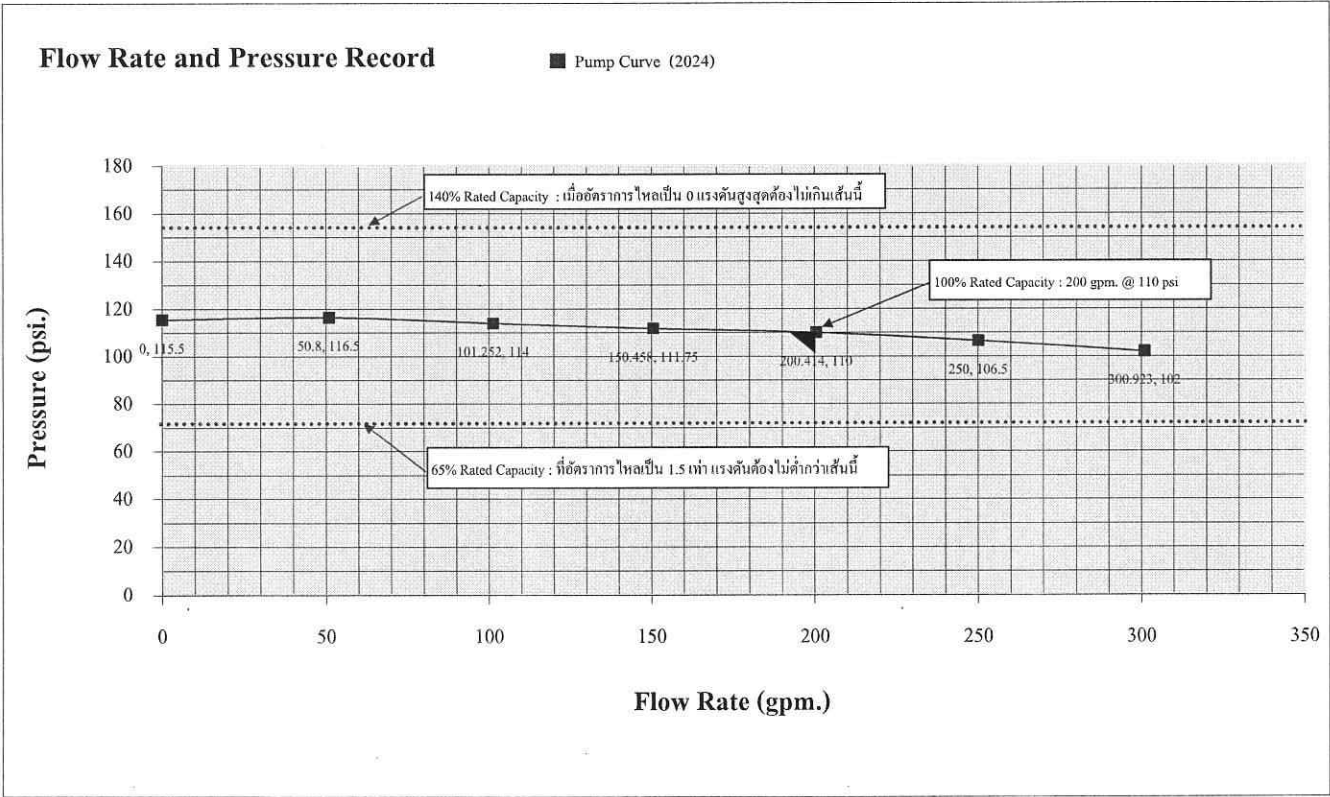
Pump Number : ELECTRIC MOTOR FIRE PUMP

Test Date : June 14, 2024

Location : Fire Pump Room

ผลสรุปจากกราฟการทดสอบวัดค่าอัตราการไหล (Flow Rate) กับแรงดันของเครื่องสูบน้ำดับเพลิง (Net Pressure) ผลปรากฏว่า

- กราฟจากการทดสอบวัดค่าอัตราการไหลของเครื่องสูบน้ำดับเพลิง (โดยใช้เครื่องมือวัดอัตราการไหล "ULTRA SONIC" Flow Meter) พบว่าเครื่องสูบน้ำดับเพลิงนี้ มีคุณสมบัติ เป็นเครื่องสูบน้ำดับเพลิง ตามมาตรฐาน NFPA.20 (อ้างอิง Figure A.6.2 Pump Characteristics Curves.)
- จากกราฟการทดสอบวัดค่าอัตราการไหล (Flow Rate) กับแรงดันของเครื่องสูบน้ำดับเพลิง (Net Pressure) พบว่า ไม่สามารถทำการวิเคราะห์ผลเปรียบเทียบค่าที่ได้กับกราฟของผู้ผลิต เนื่องจากไม่มีข้อมูลกราฟ (Original Pump Curve) ของเครื่องสูบน้ำดับเพลิงดังกล่าว

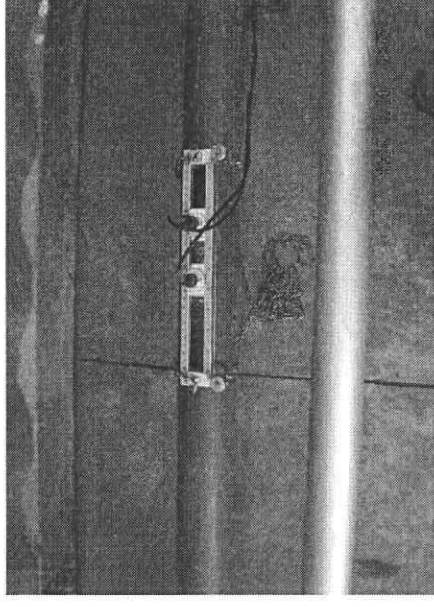


2. ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

ก่อนทำการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

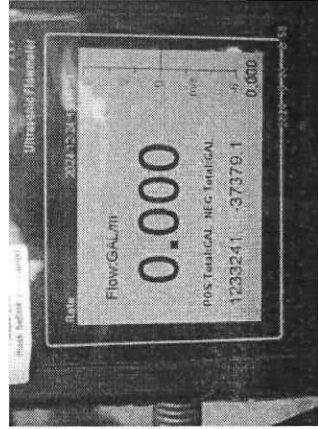


รูปที่ 1 การติดตั้งเซ็นเซอร์ (Sensor) ของเครื่องมือวัดอัตราการไหลของน้ำ (Flow Rate) ภายในเส้นท่อน้ำดับเพลิง

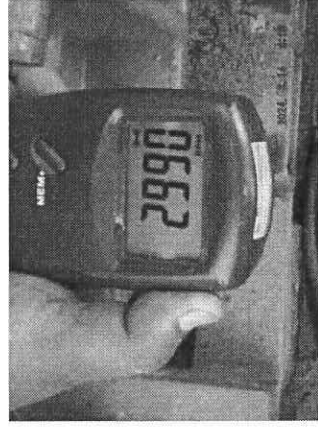
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

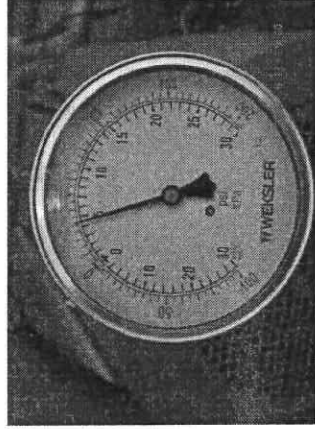
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ค่าที่ 1 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 0%)



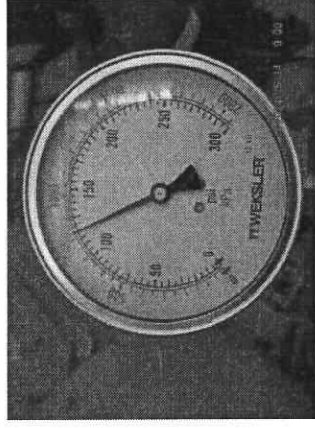
รูปที่ 1 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 0 แกลลอนต่อนาที (gpm.)



รูปที่ 2 ความเร็วรอบของมอเตอร์ (Motor Speed) ที่อ่านค่าได้เท่ากับ 2,990 รอบต่อนาที (rpm.)



รูปที่ 3 Suction Pressure ที่อ่านค่าได้เท่ากับ 4.5 psi.



รูปที่ 4 Discharge Pressure ที่อ่านค่าได้เท่ากับ 120 psi.

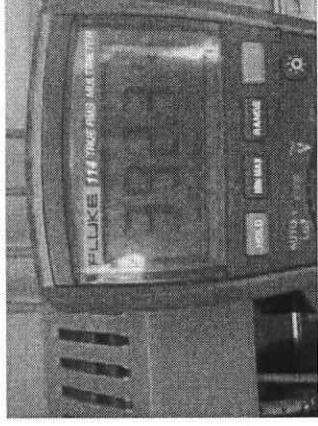
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ค่าที่ 1 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 0%)



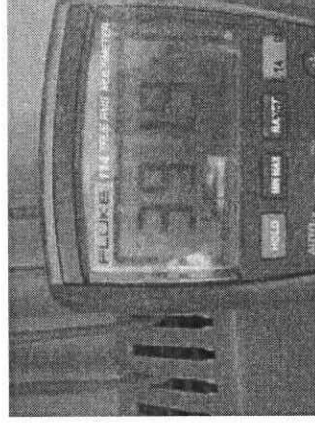
รูปที่ 5 กระแสมอเตอร์ไฟ ส. ที่อ่านค่าได้เท่ากับ 29.65 Amp.



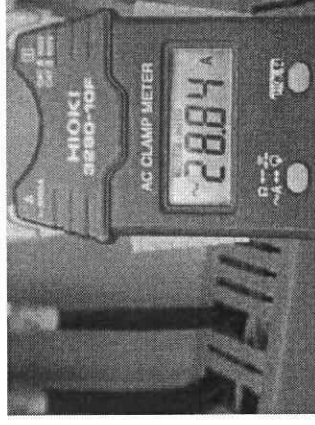
รูปที่ 6 แรงดันไฟฟ้าไฟ ส. ที่อ่านค่าได้เท่ากับ 392.3 Volt.



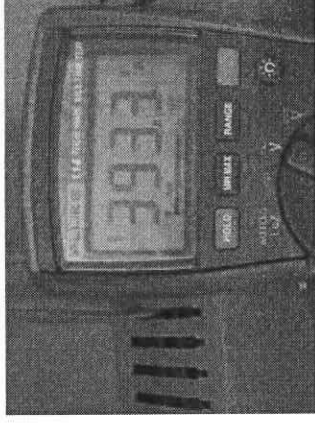
รูปที่ 7 กระแสมอเตอร์ไฟ ส. ที่อ่านค่าได้เท่ากับ 28.36 Amp.



รูปที่ 8 แรงดันไฟฟ้าไฟ ส. ที่อ่านค่าได้เท่ากับ 391.9 Volt.



รูปที่ 9 กระแสมอเตอร์ไฟ ส. ที่อ่านค่าได้เท่ากับ 28.84 Amp.



รูปที่ 10 แรงดันไฟฟ้าไฟ ส. ที่อ่านค่าได้เท่ากับ 393.3 Volt.

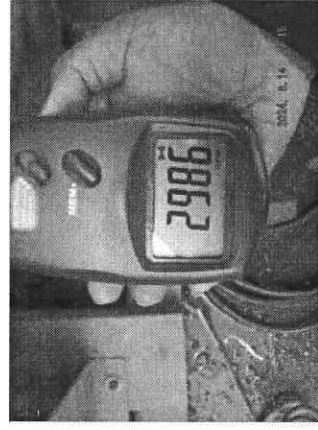
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

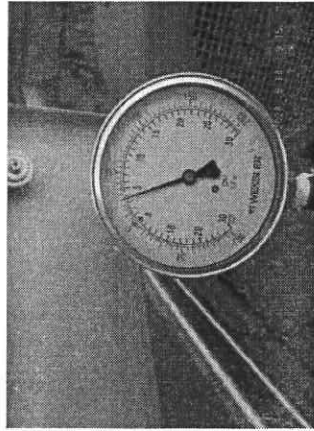
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ถ้าที่ 2 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 25%)



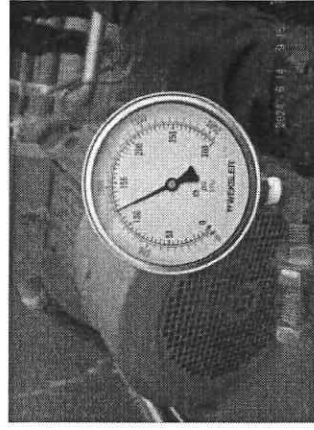
รูปที่ 11 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 50.800 แกลลอนต่อนาที (gpm.)



รูปที่ 12 ความเร็วรอบของมอเตอร์ (Motor Speed) ที่อ่านค่าได้เท่ากับ 2,986 รอบต่อนาที (rpm.)



รูปที่ 13 Suction Pressure ที่อ่านค่าได้เท่ากับ 3.5 psi.

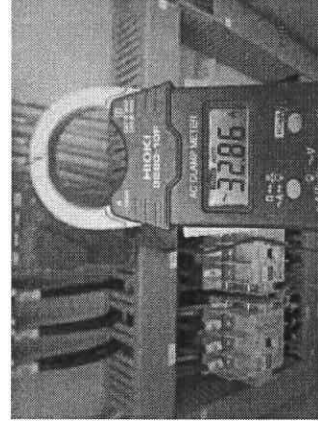


รูปที่ 14 Discharge Pressure ที่อ่านค่าได้เท่ากับ 120 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

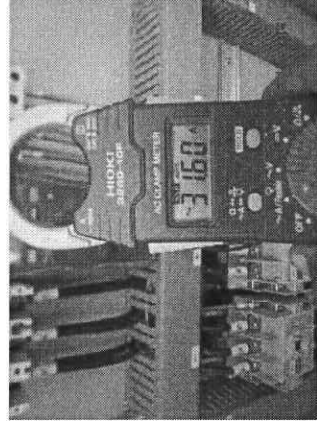
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ถ้าที่ 2 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 25%)



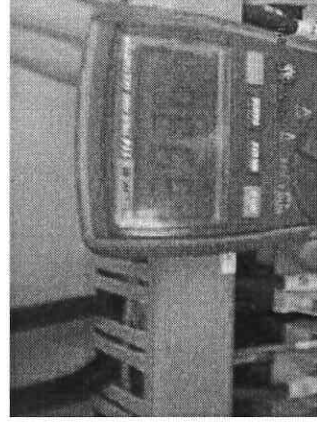
รูปที่ 15 กระแสมอเตอร์เฟส R. ที่อ่านค่าได้เท่ากับ 32.86 Amp.



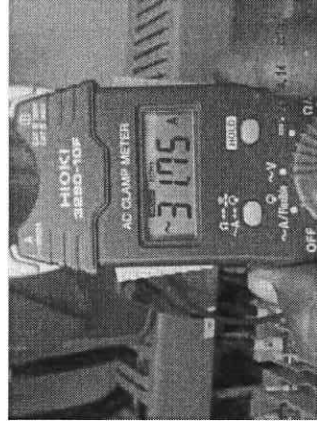
รูปที่ 16 แรงดันไฟฟ้าเฟส RS. ที่อ่านค่าได้เท่ากับ 393.4 Volt.



รูปที่ 17 กระแสมอเตอร์เฟส S. ที่อ่านค่าได้เท่ากับ 31.60 Amp.



รูปที่ 18 แรงดันไฟฟ้าเฟส ST. ที่อ่านค่าได้เท่ากับ 393.6 Volt.



รูปที่ 19 กระแสมอเตอร์เฟส T. ที่อ่านค่าได้เท่ากับ 31.75 Amp.

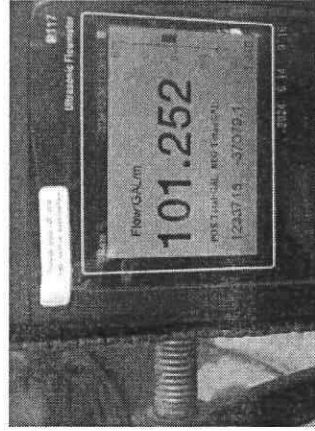


รูปที่ 20 แรงดันไฟฟ้าเฟส RT. ที่อ่านค่าได้เท่ากับ 394.9 Volt.

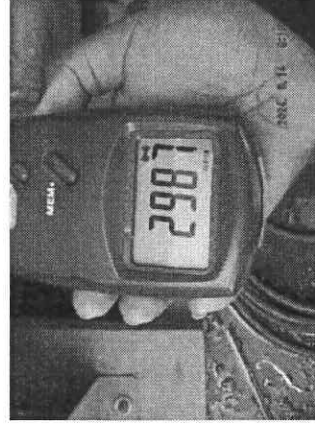
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

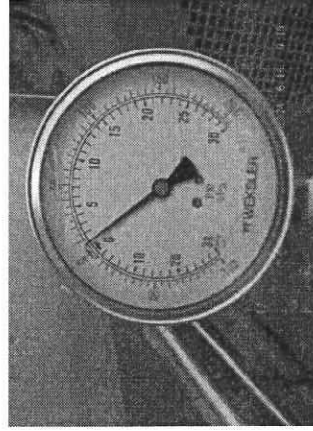
ขณะที่การทดสอบเครื่องสแกนพบผลค่า 3 (อัตราการไหลของเครื่องสแกนลดลง 50%)



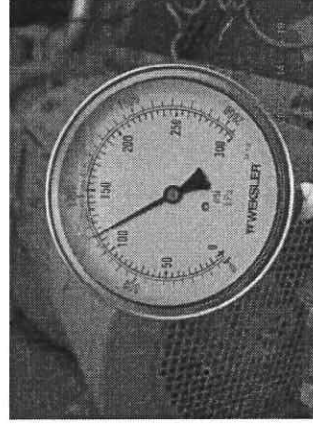
รูปที่ 21 อัตราการไหล (Flow Rate) ที่น่าสนใจ
เท่ากับ 101.252 แกลลอนต่อนาที (gpm.)



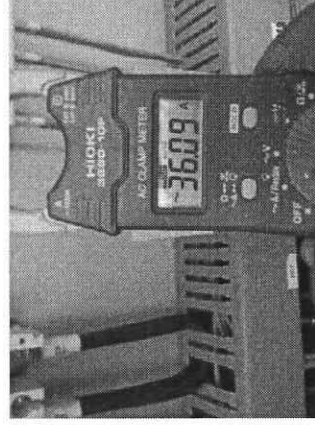
รูปที่ 22 ความเร็วรอบของมอเตอร์ (Motor Speed)
ที่อ่านค่าได้เท่ากับ 2,987 รอบต่อนาที (rpm.)



รูปที่ 23 Suction Pressure ที่อ่านค่าได้เท่ากับ 1 psi



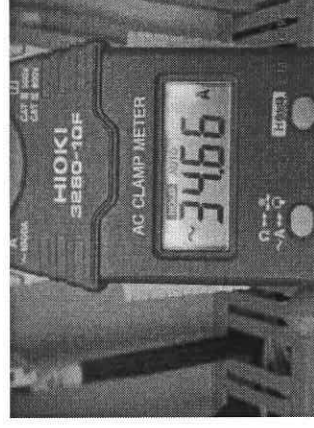
รูปที่ 24 Discharge Pressure ที่อ่านค่าได้เท่ากับ 115 psi.



รูปที่ 25 กระแสแอมเตอร์เฟส R, ที่อ่านค่าได้เท่ากับ 36.09 Amp.



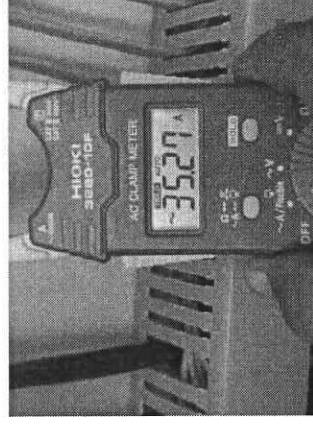
รูปที่ 26 แรงดันไฟฟ้าเฟส RS. ที่อ่านค่าได้เท่ากับ 394.2 Volt.



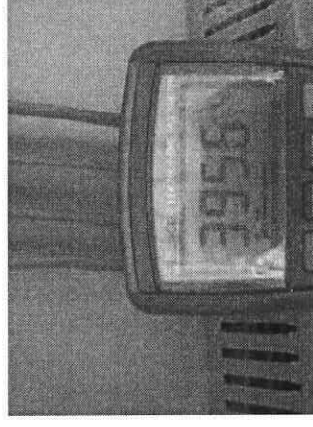
วันที่ 27 กระแสแอมแปร์เฟส S. อ่านค่าได้เท่ากับ 34.66 Amp.



วันที่ 28 แรงดันไฟฟ้าส ST. ที่อ่านค่าได้เท่ากับ 394.5 Volt.



วันที่ 29 กระแสมอเตอร์เฟส T. ที่อ่านค่าได้เท่ากับ 35.27 Amp.

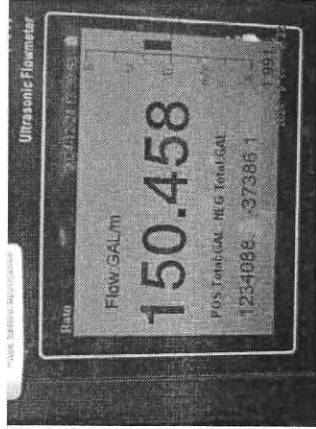


รูปที่ 30 แรงดันไฟฟ้าพล RT. ที่อ่านค่าได้เท่ากับ 395.6 Volt.

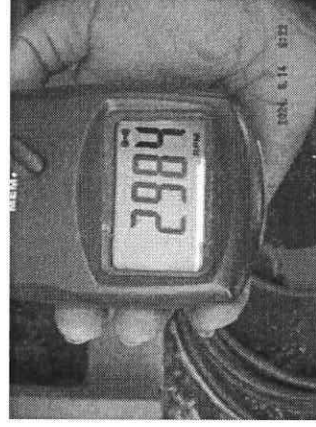
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำด้วยเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

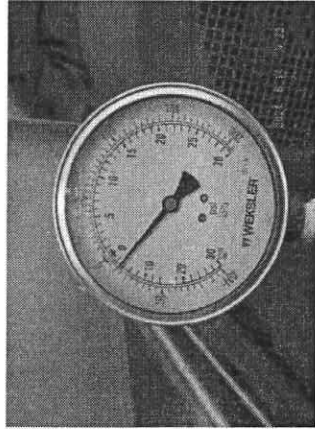
ขณะทำการทดสอบเครื่องสูบน้ำด้วยเพลิงบันทึกผล ค่าที่ 4 (อัตราการไหลของเครื่องสูบน้ำด้วยเพลิง 75%)



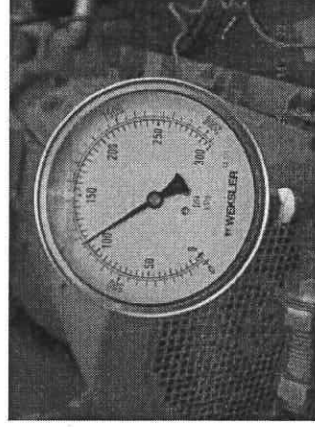
รูปที่ 31 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 150.458 แกลลอนต่อนาที (gpm.)



รูปที่ 32 ความเร็วรอบของมอเตอร์ (Motor Speed) ที่อ่านค่าได้เท่ากับ 2,984 รอบต่อนาที (rpm.)



รูปที่ 33 Suction Pressure ที่อ่านค่าได้เท่ากับ -3.5 inHg.



รูปที่ 34 Discharge Pressure ที่อ่านค่าได้เท่ากับ 110 psi.

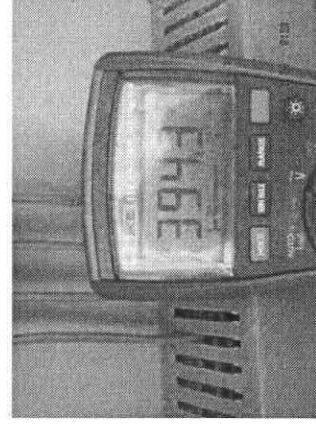
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำด้วยเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

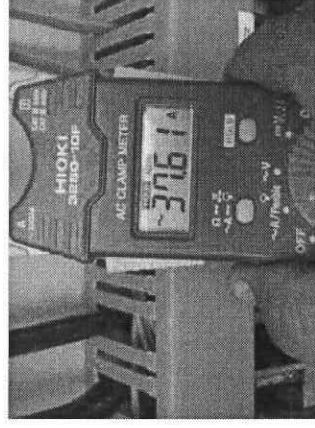
ขณะทำการทดสอบเครื่องสูบน้ำด้วยเพลิงบันทึกผล ค่าที่ 4 (อัตราการไหลของเครื่องสูบน้ำด้วยเพลิง 75%)



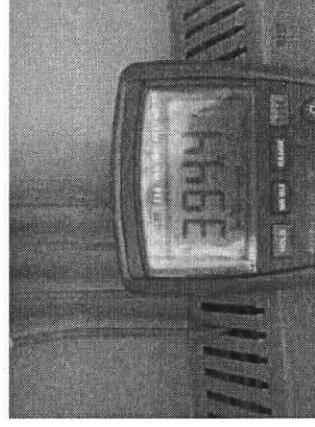
รูปที่ 35 กระแสมอเตอร์เฟส R. ที่อ่านค่าได้เท่ากับ 39.48 Amp.



รูปที่ 36 แรงดันไฟฟ้าเฟส RS. ที่อ่านค่าได้เท่ากับ 394.3 Volt.



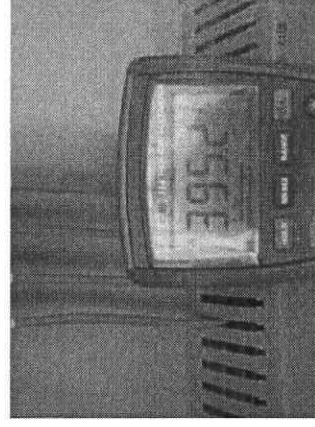
รูปที่ 37 กระแสมอเตอร์เฟส S. ที่อ่านค่าได้เท่ากับ 37.61 Amp.



รูปที่ 38 แรงดันไฟฟ้าเฟส ST. ที่อ่านค่าได้เท่ากับ 394.4 Volt.



รูปที่ 39 กระแสมอเตอร์เฟส T. ที่อ่านค่าได้เท่ากับ 37.70 Amp.

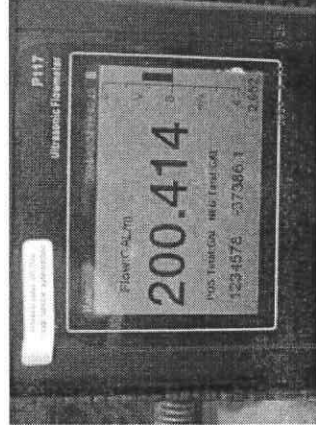


รูปที่ 40 แรงดันไฟฟ้าเฟส RT. ที่อ่านค่าได้เท่ากับ 395.2 Volt.

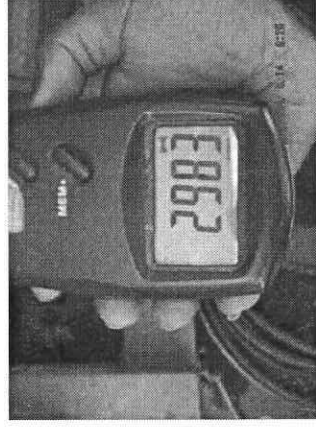
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

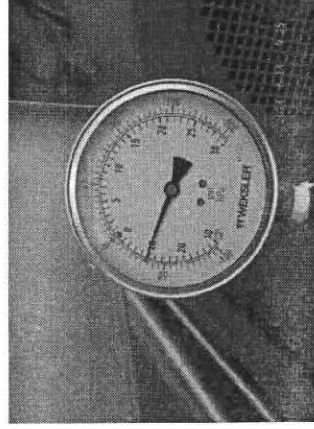
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ถ้าที่ 5 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 100%)



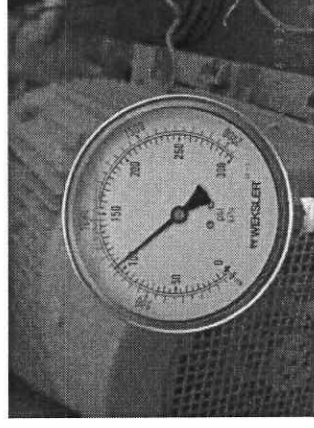
รูปที่ 41 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 200.414 แกลลอนต่อนาที (gpm.)



รูปที่ 42 ความเร็วรอบของมอเตอร์ (Motor Speed) ที่อ่านค่าได้เท่ากับ 2,983 รอบต่อนาที (rpm.)



รูปที่ 43 Suction Pressure ที่อ่านค่าได้เท่ากับ -10 inHg.



รูปที่ 44 Discharge Pressure ที่อ่านค่าได้เท่ากับ 105 psi.

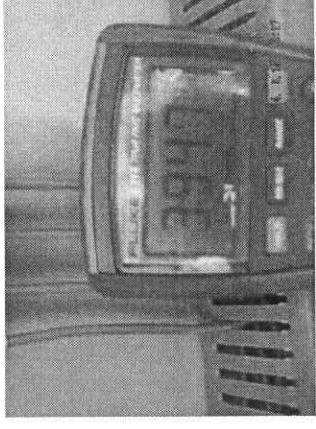
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

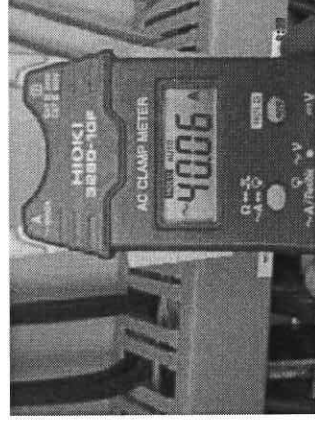
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ถ้าที่ 5 (อัตราการไหลของเครื่องสูบน้ำดับเพลิง 100%)



รูปที่ 45 กระแสมอเตอร์ไฟ R. ที่อ่านค่าได้เท่ากับ 41.47 Amp.



รูปที่ 46 แรงดันไฟฟ้าเฟส RS. ที่อ่านค่าได้เท่ากับ 394.7 Volt.



รูปที่ 47 กระแสมอเตอร์ไฟ S. ที่อ่านค่าได้เท่ากับ 40.06 Amp.



รูปที่ 48 แรงดันไฟฟ้าเฟส ST. ที่อ่านค่าได้เท่ากับ 395.3 Volt.



รูปที่ 49 กระแสมอเตอร์ไฟ T. ที่อ่านค่าได้เท่ากับ 40.89 Amp.

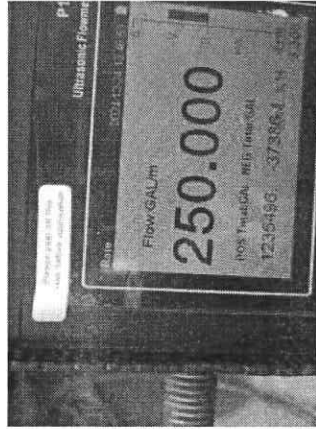


รูปที่ 50 แรงดันไฟฟ้าเฟส RT. ที่อ่านค่าได้เท่ากับ 396.0 Volt.

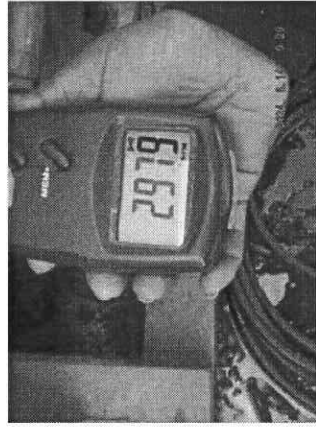
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

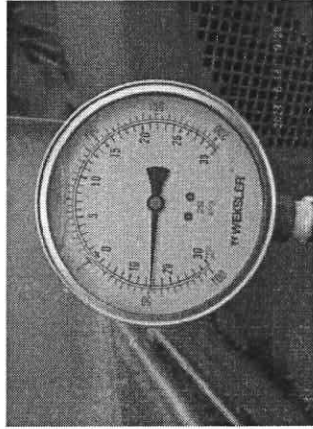
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ค่าที่ 6 (เพื่อทราบการไหลของเครื่องสูบน้ำดับเพลิง 125%)



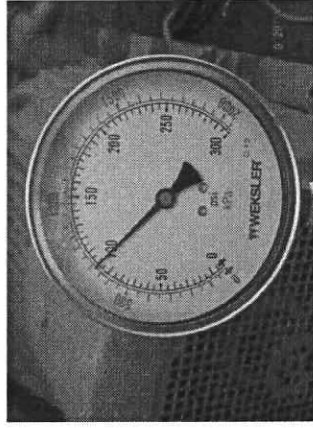
รูปที่ 51 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 250.000 แกลลอนต่อนาที (gpm.)



รูปที่ 52 ความเร็วรอบของมอเตอร์ (Motor Speed) ที่อ่านค่าได้ เท่ากับ 2,979 รอบต่อนาที (rpm.)



รูปที่ 53 Suction Pressure ที่อ่านค่าได้เท่ากับ -15 inHg.

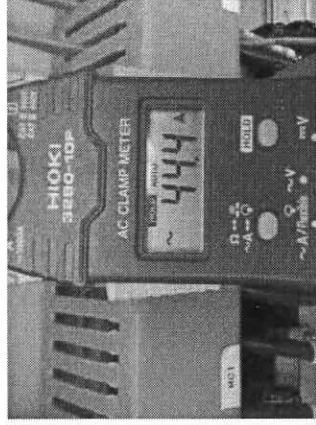


รูปที่ 54 Discharge Pressure ที่อ่านค่า ได้เท่ากับ 99 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ค่าที่ 6 (เพื่อทราบการไหลของเครื่องสูบน้ำดับเพลิง 125%)



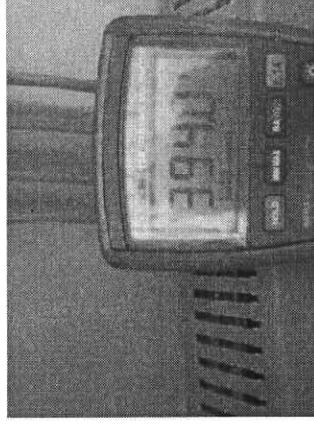
รูปที่ 55 กระแสมอเตอร์เฟส R ที่อ่านค่าได้เท่ากับ 44.4 Amp.



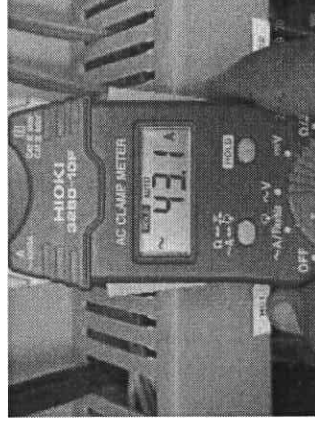
รูปที่ 56 แรงดันไฟฟ้าเฟส RS ที่อ่านค่าได้เท่ากับ 392.9 Volt.



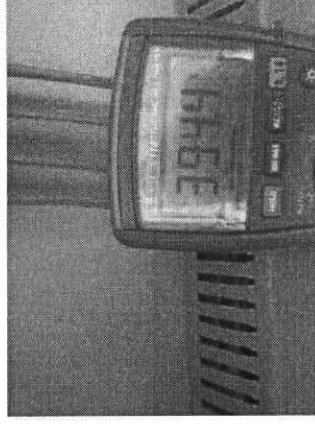
รูปที่ 57 กระแสมอเตอร์เฟส S ที่อ่านค่าได้เท่ากับ 43.6 Amp.



รูปที่ 58 แรงดันไฟฟ้าเฟส ST ที่อ่านค่าได้เท่ากับ 394.0 Volt.



รูปที่ 59 กระแสมอเตอร์เฟส T ที่อ่านค่าได้เท่ากับ 43.1 Amp.

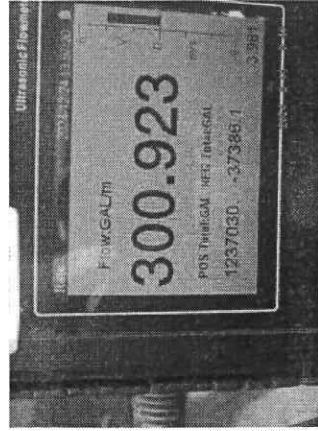


รูปที่ 60 แรงดันไฟฟ้าเฟส RT ที่อ่านค่าได้เท่ากับ 394.4 Volt.

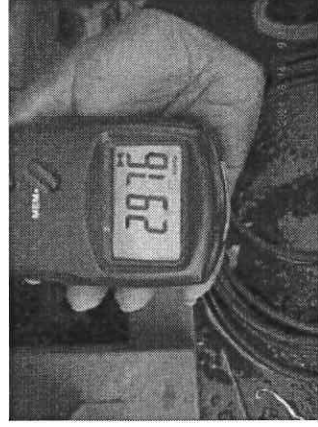
ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

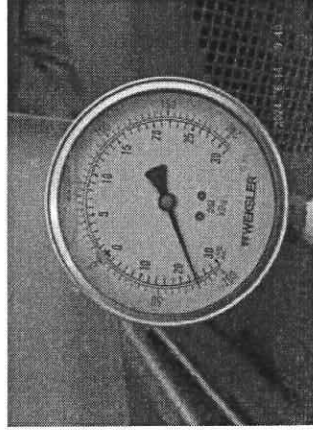
ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ค่าที่ 7 (เพื่อทราบไหลของเครื่องสูบน้ำดับเพลิง 150%)



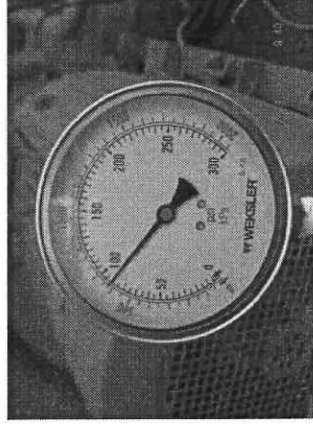
รูปที่ 61 อัตราการไหล (Flow Rate) ที่อ่านค่าได้เท่ากับ 300.923 แกลลอนต่อนาที (gpm.)



รูปที่ 62 ความเร็วรอบของมอเตอร์ (Motor Speed) ที่อ่านค่าได้เท่ากับ 2.976 รอบต่อนาที (rpm.)



รูปที่ 63 Suction Pressure ที่อ่านค่าได้เท่ากับ -24 inHg.



รูปที่ 64 Discharge Pressure ที่อ่านค่าได้เท่ากับ 90 psi.

ภาพแสดงการทดสอบประสิทธิภาพของเครื่องสูบน้ำดับเพลิง

Pump Number : ELECTRIC MOTOR FIRE PUMP

ขณะทำการทดสอบเครื่องสูบน้ำดับเพลิงบันทึกผล ค่าที่ 7 (เพื่อทราบไหลของเครื่องสูบน้ำดับเพลิง 150%)



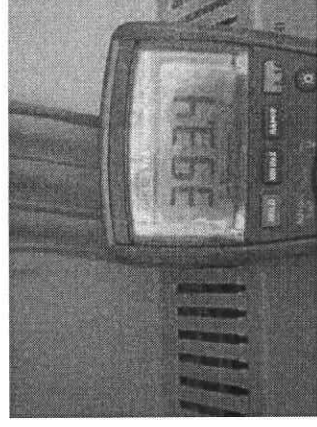
รูปที่ 65 กระแสแอมแปร์เฟส R. ที่อ่านค่าได้เท่ากับ 48.2 Amp.



รูปที่ 66 แรงดันไฟฟ้าเฟส RS. ที่อ่านค่าได้เท่ากับ 393.0 Volt.



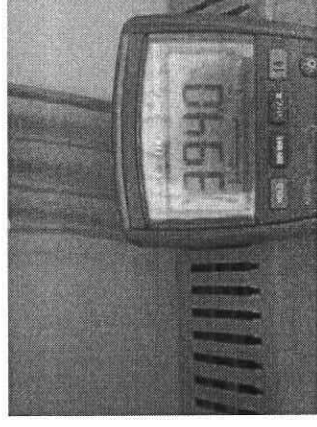
รูปที่ 67 กระแสแอมแปร์เฟส S. ที่อ่านค่าได้เท่ากับ 46.2 Amp.



รูปที่ 68 แรงดันไฟฟ้าเฟส ST. ที่อ่านค่าได้เท่ากับ 393.4 Volt.



รูปที่ 69 กระแสแอมแปร์เฟส T. ที่อ่านค่าได้เท่ากับ 46.8 Amp.



รูปที่ 70 แรงดันไฟฟ้าเฟส RT. ที่อ่านค่าได้เท่ากับ 394.0 Volt.

3. เอกสารของผู้ควบคุมงานทดสอบ

Certified 3-Point Factory Calibration

by

pFlow Technology Ltd.

This Form Represents the Calibration Data for Unit Under Test as Described Below:

Customer: Model: P118i
Serial Number: v5200869 Scale Factor: 1.000
Sales Order #: Full Scale: (0~±12)m/s

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).

4. รายละเอียดของเครื่องมือวัดที่เกี่ยวข้องกับการทดสอบ

Calibration Data for Unit Under Test

| AVERAGE FLOW FOR REFERENCE:(m³/hour) | FLOW STANDARD TOTALIZED FLOW (L) | UNIT UNDER TEST TOTALIZED FLOW (L) | SCALE (Kt) | REPEATABILITY (%) | PASSED |
|--------------------------------------|----------------------------------|------------------------------------|------------|-------------------|--------|
| 299.889 | 4998.148 | 4922.185 | 1.015 | 0.06 | YES |
| 174.787 | 2913.111 | 2864.252 | 1.017 | 0.18 | YES |
| 46.602 | 776.704 | 761.615 | 1.020 | 0.15 | YES |

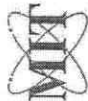
Standard Deviation: ±0.36% of Reading

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

Calibration Date: May. 21. 2024

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

Calibration Conducted By XU



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



CALIBRATION CERTIFICATE

Certificate No. : L202404189-0001
Date Issued : 22-Apr-24

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

Equipment : Pressure Gauge

Manufacturer : WEKSLER

Model : W-BY14YP14LWLJMTG

Serial No. : -

ID No./Tag No. : C24-166

Date Received : 19-Apr-24

Date Calibrated : 20-Apr-24

Calibrated by : Mr. Saruth Srichitkul

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 Miracle International Technology Company Limited.

Approved by:

(Mr. Sarayuth Tochua)

Certificate No : L202404189-0001

Environment : Ambient Temperature :
Relative Humidity :
(25 ± 2)°C
(50 ± 15)%RH

| UUC Reading | STD Reading (psi) | STD Reading (psi) | UUC Error | Uncertainty | MPE | Pass / Fail |
|-------------|-------------------|-------------------|-----------|-------------|-----|-----------------|
| psi | Before Adjusted | After Adjusted | psi | ± psi | psi | with Guard Band |
| 0 | 0.00 | - | 0.00 | 1.2 | 3.0 | Pass |
| 50 | 49.97 | - | 0.03 | 1.2 | 3.0 | Pass |
| 100 | 99.94 | - | 0.06 | 1.2 | 3.0 | Pass |
| 150 | 149.92 | - | 0.08 | 1.2 | 3.0 | Pass |
| 200 | 199.92 | - | 0.08 | 1.2 | 3.0 | Pass |
| 250 | 249.80 | - | 0.20 | 1.2 | 3.0 | Pass |
| 300 | 299.77 | - | 0.23 | 1.2 | 3.0 | Pass |

STD = Standard

UUC = Unit Under Calibration

MPE = Maximum Permissible Error

Calibrated condition :

Pressure Medium
Mounting Position
Reference Level
Conversion Factor

Pass = $|\text{error}| + |\text{uncertainty}| \leq |\text{MPE}|$

Fail = $|\text{error}| + |\text{uncertainty}| > |\text{MPE}|$

Air : Density = 1.19 kg/m³ @ 20°C, 1 bar
Vertical
at center of its dial
Multiply by 6.894 757 E+03 - Pa unit

Description of UUC :

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

Condition As-Received : New Item

The measurement results and statements of conformity with specification only relate to the item calibrated.

Measurement Standards Used & Traceability :

The International System of Units (SI) through

MIT Certificate No. L202311215-0001, L202311215-0002, L202311215-0003 for Pressure Calibrator 20 bar Serial No. 61012303,
Due 18-Nov-24

End of Certificate



MIRACLE INTERNATIONAL TECHNOLOGY CO.,LTD
214 Bangwek Rd. Bangsoi Bangkok 10160
Tel. 0-2865-4647-8 Fax. 0-2865-4649 Email: www.mit.th

CALIBRATION CERTIFICATE



Certificate No. : L202404189-0002
Date Issued : 22-Apr-24

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

Equipment : Pressure Gauge

Manufacturer : WEKSLER

Model : W-BY14YCB4L WLJLMTG

Serial No. : -

ID No./Tag No. : C24-167

Date Received : 19-Apr-24

Date Calibrated : 20-Apr-24

Calibrated by : Mr. Saruth Srichuikul

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 Miracle International Technology Company Limited.



Approved by:

(Mr. Sarayuth Tochua)

Certificate No : L202404189-0002

Environment : Ambient Temperature : (25 ± 2)°C

Relative Humidity : (50 ± 15)%RH

Negative

| UUC Reading inHg | STD Reading Before Adjusted | STD Reading After Adjusted | UUC Error inHg | Uncertainty ± inHg | MPE inHg | Pass / Fail with Guard Band |
|---------------------|--------------------------------|-------------------------------|-------------------|-----------------------|-------------|-----------------------------------|
| -30.0 | -29.98 * | - | -0.02 | 0.24 | 0.3 | Pass |
| -25.0 | -24.95 | - | -0.05 | 0.24 | 0.3 | Pass |
| -20.0 | -19.96 | - | -0.04 | 0.24 | 0.3 | Pass |
| -15.0 | -14.96 | - | -0.04 | 0.24 | 0.3 | Pass |
| -10.0 | -9.94 | - | -0.06 | 0.24 | 0.3 | Pass |
| -5.0 | -4.96 | - | -0.04 | 0.24 | 0.3 | Pass |
| 0.0 | 0.00 | - | 0.00 | 0.23 | 0.3 | Pass |

Marked * are not included in the NSC-ONSC accreditation schedule for our laboratory.

STD = Standard

Pass = $|\text{error}| + |\text{uncertainty}| \leq |\text{MPE}|$

UUC = Unit Under Calibration

Fail = $|\text{error}| + |\text{uncertainty}| > |\text{MPE}|$

MPE = Maximum Permissible Error

Calibrated condition :

Air : Density = 1.19 kg/m³ @ 20°C, 1 bar

Pressure Medium

Vertical

Mounting Position

at center of its dial

Reference Level

Multiply by 3.386 389 lbf+03 - Pa unit

Conversion Factor

Description of UUC :

Range

(-30)-0 inHg

Calibration Range

(-30)-0 inHg

Scale Interval

1 inHg

Resolution

0.2 inHg

Condition As-Received : New Item

The measurement results and statements of conformity with specification only relate to the item calibrated.

Measurement Standards Used & Traceability :

The International System of Units (SI) through

IRPC Certificate No. CL1-P230097 for Reference Pressure Monitor Serial No. 1598, Due 09-Nov-24

| | |
|-------------|-----------------------|
| Environment | Ambient Temperature : |
| | Relative Humidity : |

| Positive | UUC Reading | | STD Reading (psi) | | UUC Error | | Uncertainty | | MPE | | Pass / Fail |
|----------|-------------|--|-------------------|----------------|-----------|--|-------------|-----|-----|------|-------------|
| | psi | | Before Adjusted | After Adjusted | psi | | ± psi | psi | | | |
| | 0.0 | | 0.00 | - | 0.00 | | 0.26 | 0.3 | | Pass | |
| | 5.0 | | 4.98 | - | 0.02 | | 0.26 | 0.3 | | Pass | |
| | 10.0 | | 9.98 | - | 0.02 | | 0.26 | 0.3 | | Pass | |
| | 15.0 | | 14.99 | - | 0.01 | | 0.26 | 0.3 | | Pass | |
| | 20.0 | | 19.99 | - | 0.01 | | 0.26 | 0.3 | | Pass | |
| | 25.0 | | 24.97 | - | 0.03 | | 0.26 | 0.3 | | Pass | |
| | 30.0 | | 30.01 | - | -0.01 | | 0.26 | 0.3 | | Pass | |

| | |
|---------------------------------|--|
| STD = Standard | Pass = $ \text{error} + \text{uncertainty} \leq \text{MPE} $ |
| UUC = Unit Under Calibration | Fail = $ \text{error} + \text{uncertainty} > \text{MPE} $ |
| MPE = Maximum Permissible Error | |
| Calibrated condition : | Air : Density = 1.19 kg/m ³ @ 20°C, 1 bar |
| Pressure Medium | Vertical |
| Mounting Position | at center of its dial |
| Reference Level | Multiply by 0.894 757 E+03 – Pa unit |
| Conversion Factor | |

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

Condition As-Received : New Item

The measurement results and statements of conformity with specification only relate to the item calibrated.

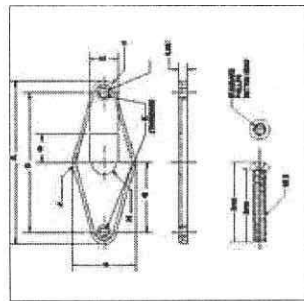
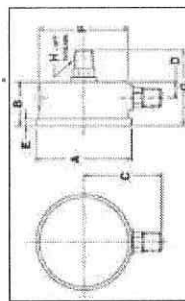
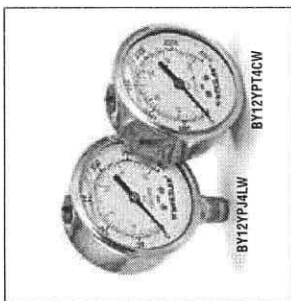
The International System of Units (SI) through
 MFT Certificate No. L202311215-0001, L202311215-0002, L202311215-0003 for Pressure Calibrator 20 bar Serial No. 61012303,
 Due 18-Nov-24

End of Certificate

Page 3 of 3

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**Liquid Filled Gauges, SS Case
Bronze Tube, Brass Socket
+3-2-3% Accuracy**



STANDARD FEATURES

- Available in 40mm, 50mm, 63mm and 100mm sizes
- Stainless steel case and ring with plastic window
- Dual scale dials with bar/kPa in blue (inner scale); psi in black (outer scale), on white background
- Panel mount kits available
- ¼ NPT back connection available in 40mm size; ¼ NPT lower and back connection available in 50mm and 63mm sizes; ½ NPT lower connection available in 100mm size.

CATALOG NUMBERS

| Ball Size | Conversion Factor | Conversion Error | Alpha | | Sigma | | Beta | | Gamma | | Delta | |
|--|-------------------|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| | | | Ball | % | Ball | % | Ball | % | Ball | % | Ball | % |
| 30-36 mm (1 1/8" to 1 3/8") (1000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 36-42 mm (1 3/8" to 1 5/8") (1500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 42-48 mm (1 5/8" to 1 7/8") (2000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 48-54 mm (1 7/8" to 2") (2500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 54-60 mm (2" to 2 1/8") (3000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 60-66 mm (2 1/8" to 2 1/4") (3500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 66-72 mm (2 1/4" to 2 3/8") (4000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 72-78 mm (2 3/8" to 2 7/8") (4500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 78-84 mm (2 7/8" to 3") (5000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 84-90 mm (3" to 3 1/8") (5500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 90-96 mm (3 1/8" to 3 1/4") (6000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 96-102 mm (3 1/4" to 3 3/8") (6500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 102-108 mm (3 3/8" to 3 1/2") (7000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 108-114 mm (3 1/2" to 3 3/4") (7500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 114-120 mm (3 3/4" to 3 1/2") (8000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 120-126 mm (3 1/2" to 3 1/4") (8500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 126-132 mm (3 1/4" to 3 3/8") (9000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 132-138 mm (3 3/8" to 3 1/2") (9500 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |
| 138-144 mm (3 1/2" to 3 1/4") (10000 kg) | — | — | B1117C630 | B1117C630 | B1117C640 | B1117C640 | B1117C650 | B1117C650 | B1117C660 | B1117C660 | B1117C670 | B1117C670 |

To order, specify 10-digit "catalog number" from above table. For panel mount gauges (back connection only) add "-UC" to 10-digit catalog number.

GAUGE DIMENSIONS RV10Y RV11V RV12V RV14V

| Lower Connection Gauge Size Type | | A | B | C | D-1/4 | E | F |
|----------------------------------|-------------|------------|------------|------------|------------|------------|------------|
| 50 mm | BV11Y mm | 2.21 mm | 1.11 mm | 1.86 mm | 0.37 mm | 0.19 mm | 2.01 mm |
| 63 mm | BV12Y mm | 2.62 mm | 1.13 mm | 2.08 mm | 0.39 mm | 0.22 mm | 2.45 mm |
| | | 66 mm | 29 mm | 53 mm | 10 mm | 5 mm | 75 mm |
| 100 mm | BV14Y mm | 4.29 mm | 1.42 mm | 3.14 mm | 0.46 mm | 0.29 mm | 3.88 mm |
| | | 109 mm | 36 mm | 80 mm | 12 mm | 7 mm | 98 mm |

| Base Connection Gauge Size Type | | A | B | F | G | H |
|---------------------------------|-------------|------------|------------|------------|------------|-----|
| 40 mm | BV10Y mm | 1.78 mm | 1.00 mm | 1.51 mm | 1.62 mm | |
| | | 45 mm | 25 mm | 41 mm | 41 mm | 1/4 |
| 50 mm | BV11Y mm | 2.21 mm | 1.11 mm | 2.02 mm | 2.05 mm | 1/4 |
| | | 56 mm | 28 mm | 51 mm | 52 mm | |
| 63 mm | BV12Y mm | 2.62 mm | 1.13 mm | 2.45 mm | 2.05 mm | 1/4 |
| | | 66 mm | 29 mm | 62 mm | 52 mm | |

PANEL MOUNT ASSEMBLY FOR 40mm, 50mm, 63mm GAUGES

| Part No. | A | B | C | D | E | F | G | H | J | K | |
|----------|------|------|-----|------|------|------|------|------|------|-------|-------|
| 40mm | 2.36 | 1.02 | 189 | 0.45 | 0.44 | 0.94 | 0.94 | 0.20 | 0.10 | M50/8 | |
| 40mm | 2.36 | 1.26 | 48 | 11.6 | 11.3 | 24 | 24 | 5 | 2.50 | M50/8 | |
| 50mm | 2.83 | 1.26 | 238 | 0.57 | 0.56 | 0.47 | 1.18 | 0.24 | 0.10 | M50/8 | |
| 50mm | 2.83 | 1.26 | 32 | 60 | 14.6 | 14.2 | 30 | 72 | 6 | 2.50 | M50/8 |
| 50mm | 3.27 | 1.26 | 280 | 0.57 | 0.56 | 0.47 | 1.40 | 0.24 | 0.10 | M50/8 | |
| 50mm | 3.27 | 1.26 | 280 | 0.57 | 0.56 | 0.47 | 1.40 | 0.24 | 0.10 | M50/8 | |
| 50mm | 3.27 | 1.26 | 280 | 0.57 | 0.56 | 0.47 | 1.40 | 0.24 | 0.10 | M50/8 | |

NFPA®

20

Standard for the
Installation of
Stationary Pumps
for Fire Protection

2019



5. รายละเอียดข้อมูล NFPA. 20 & NFPA.25 (ที่เกี่ยวข้อง)

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NFPA 20

Standard for the

Installation of Stationary Pumps for Fire Protection

2019 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 E. 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 E.

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 supplies, 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 retroactively 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 *Liter* and *bar* 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.

1.6.5 **Trade Sizes.** Where industry utilizes nominal dimensions to represent materials, products, or performance, direct

3.3.67.2* *Transfer Switch.*

3.3.67.2.1 *Automatic Transfer Switch (ATS).* Self-acting equipment for transferring the connected load from one power source to another power source. [110, 2013]

3.3.67.2.2 *Manual Transfer Switch.* A switch operated by direct manpower for transferring one or more load conductors from one power source to another.

3.3.68* *Torsional Coupling.* A driveline component capable of transmitting torque having a very low spring constant along the axis of rotation to detune the driveline and move any damaging resonances safely below operating speed.

3.3.69 **Total Discharge Head (h_d).** See 3.3.29.2.

3.3.70 **Total Head (H), Horizontal Pumps.** See 3.3.29.3.1.

3.3.71 **Total Head (H), Vertical Turbine Pumps.** See 3.3.29.3.2.

3.3.72 **Total Rated Head.** See 3.3.29.4.

3.3.73 **Total Suction Head (h_s).** See 3.3.29.5.

3.3.74 **Total Suction Lift (h_L).** Suction lift that exists where the total suction head is below atmospheric pressure. Total suction lift, as determined on test, is the reading of a liquid manometer at the suction nozzle of the pump, converted to feet (meters) of liquid, and referred to datum, minus the velocity head at the point of gauge attachment.

3.3.75 **Valve.**

3.3.75.1 *Dump Valve.* An automatic valve installed on the discharge side of a positive displacement pump to relieve pressure prior to the pump driver reaching operating speed.

3.3.75.2 *Pressure Control Valve.* A pilot-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, 2016]

3.3.75.3 *Pressure-Reducing Valve.* A valve designed for the purpose of reducing the downstream water pressure under both flowing (residual) and nonflowing (static) conditions. [14, 2016]

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

3.3.75.4.1 *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.

3.3.75.5 *Suction Pressure Regulating Valve.* A pilot-operated valve installed in discharge piping that maintains positive pressure in the suction piping, while monitoring pressure in the suction piping through a sensing line.

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

3.3.76 **Variable Speed Pumps and Controllers.**

3.3.76.1 *Self-Regulating Control.* The portion of a self-regulating variable speed fire pump unit that controls the pump speed and power.

3.3.76.2* *Self-Regulating Variable Speed Fire Pump Unit.* A factory-built integrated fire pump unit consisting of pump, driver, and variable speed control unit, configured to maintain the set pressure until the maximum power draw is reached, while acting as a variable speed pressure limiting control and/or a variable speed suction limiting control.

3.3.76.3 *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.

3.3.76.4 *Variable Speed Pump.* A fire pump with variable speed pressure limiting control or a self-regulating variable speed fire pump unit.

3.3.76.5 *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.

3.3.77 **Velocity Head (h_v).** See 3.3.29.6.

3.3.78 **Vertical Fire Protection Zone.** A vertical zone within a high-rise building that is supplied from a fire pump(s) and/or water storage tank(s).

3.3.79 **Very Tall Building.** A high-rise building where the fire protection water demand exceeds the pumping capacity of the fire department.

3.3.80 **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* Means shall be provided for qualified personnel to determine that the fire pump is operating in a satisfactory manner during pump operation.

4.3.2 System Designer.

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 authority having jurisdiction.

4.3.3 System Installer.

4.3.3.1 Installation personnel shall be qualified or shall be supervised by persons who are qualified in the installation, inspection, and testing of fire protection systems.

4.3.3.2 Minimum evidence of qualifications or certification shall be provided when requested by the authority having jurisdiction.

4.3.3.3 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 installation 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

4.3.3.4 Additional evidence of qualification or certification shall be permitted to be required by the authority having jurisdiction.

4.3.4* Service Personnel Qualifications and Experience.

4.3.4.1 Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire protection systems.

4.3.4.2 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 servicing 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) Personnel who are employed and qualified by an organization listed by a nationally recognized testing laboratory for the servicing of fire protection systems

4.3.4.3 Additional evidence of qualification or certification shall be permitted to be required by the authority having jurisdiction.

4.4 Fire Pump Unit Performance.

4.4.1* The fire pump unit, consisting of a pump, driver, and controller, shall perform in compliance with this standard as an entire unit when installed or when components have been replaced.

4.4.2 The complete fire pump unit shall be field acceptance tested for proper performance in accordance with the provisions of this standard. (See Section 14.2.)

4.4.3* A single entity shall be designated as having responsibility for acceptable unit performance of the pump, driver, controller, and transfer switch equipment as required by this standard.

4.5 Certified Shop Test.

4.5.1 Certified shop test curves showing head capacity and brake horsepower of the pump shall be furnished by the manufacturer to the purchaser.

4.5.1.1 For water mist positive displacement pumping units, certified shop test data, including flow, pressure, and horsepower, shall be provided for each independent pump.

4.5.1.2 For a multistage multipoint pump, certified shop test data that include flow, pressure, and horsepower shall be provided for each outlet.

4.5.1.3 For water mist positive displacement pumping units, certified shop test data, including flow, pressure, and horsepower, shall also be provided for the fire pump unit with variable speed features deactivated.

4.5.1.3.1 The certified fire pump unit shop test data shall be developed by activating the individual fire pumps in the same operating sequence that the controller will utilize.

4.5.1.4 For water mist positive displacement pumping units with variable speed features, certified shop test data, including flow, pressure, and horsepower, shall also be provided for the fire pump unit with variable speed features activated.

4.5.1.4.1 The certified fire pump unit shop test data shall be developed by activating the individual fire pumps in the same operating sequence that the controller will utilize.

4.5.1.5* For self-regulating variable speed fire pump units, two additional certified test curves showing the flow, net pressure, power, and speed shall be provided for each pump operating under the following conditions:

- (1) In self-regulating variable speed mode with the pump unit operating at constant discharge pressure, as measured by the discharge pressure transducer, through the design duty, and all flow rates from churn beyond 150 percent of rated flow until the maximum power draw is reached
- (2) In self-regulating variable speed mode with the pump unit operating at constant boost pressure through the design duty, and all flow rates from churn beyond 150 percent of rated flow until the maximum power draw is reached

4.5.2 The purchaser shall furnish the data required in 4.5.1 to the authority having jurisdiction.

4.6 Liquid Supplies.

4.6.1* Reliability.

4.6.1.1 The adequacy and dependability of the water source are of primary importance and shall be fully determined, with due allowance for its reliability in the future.

4.6.1.2 Where a water flow test is used to determine the adequacy of the attached water supply, the test shall have been completed not more than 12 months prior to the submission of working plans, unless otherwise permitted by the authority having jurisdiction.

4.6.2* Sources.

4.6.2.1 Any source of water that is adequate in quality, quantity, and pressure shall be permitted to provide the supply for a fire pump.

4.6.2.2 Where the water supply from a public service main is not adequate in quality, quantity, or pressure, an alternative water source shall be provided.

4.6.2.3 The adequacy of the water supply shall be determined and evaluated prior to the specification and installation of the fire pump.

4.6.2.3.1* Where the maximum flow available from the water supply main cannot provide a flow of 150 percent of the rated flow of the pump at the lowest permissible suction pressure, but the water supply can provide the greater of 100 percent of rated flow or the maximum flow demand of the fire protection system(s) at the lowest permissible suction pressure, the water supply shall be deemed to be adequate.

4.6.2.3.2 The available flow at the fire pump discharge at the lowest permissible suction pressure shall be a minimum of 100 percent of rated flow.

4.6.2.3.3 The available flow and pressure at the fire pump discharge shall be adequate to meet the maximum fire protection demand.

4.6.2.4 For liquids other than water, the liquid source for the pump shall be adequate to supply the maximum required flow rate for any simultaneous demands for the required duration and the required number of discharges.

4.6.3 Level. The minimum water level of a well or wet pit shall be determined by pumping at not less than 150 percent of the fire pump rated capacity.

4.6.4* Stored Supply.

4.6.4.1 A stored supply plus reliable automatic refill shall be sufficient to meet the demand placed upon it for the design duration.

4.6.4.2 A reliable method of replenishing the supply shall be provided.

4.6.5 Head.

4.6.5.1 Except as provided in 4.6.5.2, the head available from a water supply shall be figured on the basis of a flow of 150 percent of rated capacity of the fire pump.

4.6.5.2 Where the water supply cannot provide a flow of 150 percent of the rated flow of the pump at the lowest permissible suction pressure, but the water supply can provide the greater of 100 percent of the rated flow or the flow demand of the fire protection system(s) at the lowest permissible suction pressure, the head available from the water supply shall be permitted to be calculated on the basis of the maximum flow available at the lowest permissible suction pressure.

4.6.5.3 The head described in 4.6.5.1 and 4.6.5.2 shall be as indicated by a flow test.

4.7 Pumps, Drivers, and Controllers.

4.7.1* Fire pumps shall be dedicated to and listed for fire protection service.

4.7.2 Acceptable drivers for pumps at a single installation shall be electric motors, diesel engines, steam turbines, or a combination thereof.

4.7.3* A pump shall not be equipped with more than one driver.

4.7.4 Each fire pump shall have its own dedicated driver unless otherwise permitted in 8.6.3.1.

4.7.5 Each driver or water mist positive displacement pumping unit shall have its own dedicated controller.

4.7.6* The driver shall be selected in accordance with 9.5.2 (electric motors), 11.2.2 (diesel engines), or 13.1.2 (steam turbines) to provide the required power to operate the pump at rated speed and maximum pump load under any flow condition.

4.7.7* Maximum Pressure for Centrifugal Pumps.

4.7.7.1 The net pump shutoff (churn) pressure plus the maximum static suction pressure, adjusted for elevation, shall not exceed the pressure for which the system components are rated.

4.7.7.2* Pressure relief valves and pressure-regulating devices in the fire pump installation shall not be used as a means to meet the requirements of 4.7.7.1.

4.7.7.3 Variable Speed Pump.

4.7.7.3.1 Variable speed pumps, as defined in this standard, shall be acceptable to limit system pressure.

4.7.7.3.2* The set pressure plus the maximum pressure variance during variable speed operation and adjusted for elevation shall not exceed the pressure rating of any system component.

4.8 Self-Regulating Variable Speed Fire Pump Units.

4.8.1 Each variable speed self-regulating control unit shall maintain the factory-certified test data for variable speed operating conditions.

4.8.2 A self-regulating variable speed fire pump unit shall be factory assembled and listed as a unit.

4.8.3 Each self-regulating variable speed fire pump unit shall be provided with an across-the-line fire pump controller in accordance with Chapter 10.

4.8.4 When alternate power is provided for the pump, an across-the-line combination fire pump controller/transfer switch designed and installed in accordance with Chapter 10 shall be provided.

4.8.5 As a minimum, each variable speed drive control unit shall be provided in a National Electrical Manufacturers Association (NEMA), Type 4, watertight enclosure with an ingress protection (IP) rating of IP66.

4.8.6 Each self-regulating variable speed fire pump unit shall be provided with a minimum of 5 percent line reactance on the input.

4.8.7 The current rating of the variable frequency drive (VFD) shall not be exceeded when operating in the motor service factor.

4.8.8 Self-regulating variable speed fire pump units shall monitor the suction pressure, discharge pressure, the power draw, and the calculated flow rate and provide a supervisory alarm signal to the controller whenever the results do not match the design curve of the unit.

4.8.9 Self-regulating variable speed fire pump units shall monitor the variable speed drive and provide a supervisory

alarm signal to the controller whenever any of the following conditions occur:

- (1) Pump run
- (2) High temperature
- (3) Overcurrent
- (4) Overvoltage
- (5) Undervoltage
- (6) Ground fault
- (7) Phase loss
- (8)* Set pressure not met
- (9) Overpressure
- (10) Bypass mode

4.8.9.1 Remote contacts that close to indicate an alarm shall be provided for connection to the controller.

4.8.10 A self-regulating variable speed fire pump unit shall have a visible display panel capable of showing, as a minimum, set pressure, maximum permissible power draw, all phase-to-phase voltages, all phase amperages, boost pressure, calculated rpm, calculated flow, alerts, and faults with an accuracy within ± 2 percent.

4.8.11 Suction and discharge transducers for self-regulating variable speed fire pump units shall be provided and protected from mechanical damage.

4.8.12 Self-regulating variable speed fire pump units shall capture and maintain all operating information for a minimum of 2 years.

4.8.13 A minimum clear working space in accordance with 110.26(A)(1) of NFPA 70 shall be provided for the pump, variable speed driver, and self-regulating control unit.

4.8.14 The unit shall have no resonant first-order harmonic critical speed below 120 percent of maximum operating speed in either self-regulating or manual operator mode, whichever is greater.

4.8.15 Means shall be provided on each self-regulating variable speed fire pump unit to field adjust the set pressure.

4.8.15.1 The adjustment shall be secured by password protection or other equivalent means.

4.8.16* When operating under no-flow conditions, each self-regulating variable speed fire pump unit shall operate at a speed that provides at least 25 percent of its rated pressure.

4.8.17 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.

4.8.18 All motor-starting contactors shall comply with 10.4.5.1.

4.8.19 An automatic bypass shall be provided in accordance with 10.10.3 and 10.10.4.2.

4.8.20 An emergency-run mechanical control shall be provided in accordance with 10.5.3.2.

4.8.21 Circuit protection shall be provided in the VFD path in accordance with 10.10.5.

4.8.22 The assembly shall be marked with the short-circuit current rating.

4.8.23 Local control shall be in accordance with 10.10.7.1 and 10.10.7.3.

4.8.24 The maximum operating frequency shall not exceed line frequency.

4.9 Multistage Multiport Pump.

4.9.1 Multistage multiport fire pumps shall be installed in accordance with this standard.

4.9.2 A shutoff valve shall not be required between the impellers of a multistage multiport pump.

4.10* Centrifugal Fire Pump Capacities.

4.10.1 A centrifugal fire pump for fire protection shall be selected so that the greatest single demand for any fire protection system connected to the pump is less than or equal to 150 percent of the rated capacity (flow) of the pump.

4.10.2* Centrifugal fire pumps shall have one of the rated capacities in gpm (L/min) identified in Table 4.10.2 and shall be rated at net pressures of 40 psi (2.7 bar) or more.

4.10.3 Centrifugal fire pumps with ratings over 5000 gpm (18,925 L/min) shall be subject to individual review by either the authority having jurisdiction or a listing laboratory.

4.11 Nameplate.

4.11.1 Pumps shall be provided with a nameplate.

4.11.2 The name plate shall be made of and attached using corrosion resistant material.

4.11.3 The nameplate shall indicate the maximum pump horsepower demand required to power the pump at any flow, including flows beyond 150 percent of the rated capacity.

4.12 Pressure Gauges.

4.12.1 Discharge.

4.12.1.1 A pressure gauge having a dial not less than 3.5 in. (89 mm) in diameter shall be connected near the discharge casing with a nominal 0.25 in. (6 mm) gauge valve.

4.12.1.2 The dial shall indicate pressure to at least twice the rated working pressure of the pump but not less than 200 psi (13.8 bar).

4.12.1.3 The face of the dial shall read in bar, pounds per square inch, or both with the manufacturer's standard gradations.

4.12.2* Suction.

4.12.2.1 Unless the requirements of 4.12.2.4 are met, a gauge having a dial not less than 3.5 in. (89 mm) in diameter shall be connected to the suction pipe near the pump with a nominal 0.25 in. (6 mm) gauge valve.

4.12.2.1.1 Where the minimum pump suction pressure is below 20 psi (1.3 bar) under any flow condition, the suction gauge shall be a compound pressure and vacuum gauge.

4.12.2.2 The face of the dial shall read in inches of mercury (millimeters of mercury) or psi (bar) for the suction range.

4.12.2.3 The gauge shall have a pressure range two times the rated maximum suction pressure of the pump.

4.12.2.4 The requirements of 4.12.2 shall not apply to vertical shaft turbine-type pumps taking suction from a well or open wet pit.

4.13 Circulation Relief Valve.

4.13.1 General Requirements.

4.13.1.1* Where an electric variable speed pump is installed, the automatic circulation relief valve shall open at the minimum speed.

4.13.1.2 Unless the requirements of 4.13.1.8 are met, each pump(s) shall have an automatic relief valve listed for the fire pump service installed and set below the shutoff pressure at minimum expected suction pressure.

4.13.1.3 The valve shall be installed on the discharge side of the pump before the discharge check valve.

4.13.1.3.1 For multistage multiport pumps, the automatic circulation relief valve shall be installed before the discharge check valve for the last port and set below the churn pressure of the first port.

4.13.1.4 The valve shall provide sufficient water flow to prevent the pump from overheating when operating with no discharge.

4.13.1.5 Provisions shall be made for discharge to a drain.

4.13.1.6 Circulation relief valves shall not be tied in with the packing box or drip rim drains.

4.13.1.7 The automatic relief valve shall have a nominal size of 0.75 in. (19 mm) for pumps with a rated capacity not exceeding 2500 gpm (9462 L/min) and have a nominal size of 1 in. (25 mm) for pumps with a rated capacity of 3000 gpm to 5000 gpm (11,355 L/min to 18,925 L/min).

4.13.1.8 The requirements of 4.13.1 shall not apply to engine-driven pumps for which engine cooling water is taken from the pump discharge.

4.14* Equipment Protection.

4.14.1* General Requirements. The fire pump, driver, controller, water supply, and power supply shall be protected against possible interruption of service through damage caused by explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism, and other adverse conditions.

4.14.1.1* Indoor Fire Pump Units.

4.14.1.1.1 Except as permitted in 4.14.1.1.3, fire pump units serving high-rise buildings shall be protected from surrounding

Table 4.10.2 Centrifugal Fire Pump Capacities

| gpm | L/min | gpm | L/min |
|-----|-------|-------|--------|
| 25 | 95 | 1,000 | 3,785 |
| 50 | 189 | 1,250 | 4,731 |
| 100 | 379 | 1,500 | 5,677 |
| 150 | 568 | 2,000 | 7,570 |
| 200 | 757 | 2,500 | 9,462 |
| 250 | 946 | 3,000 | 11,355 |
| 300 | 1,136 | 3,500 | 13,247 |
| 400 | 1,514 | 4,000 | 15,140 |
| 450 | 1,703 | 4,500 | 17,032 |
| 500 | 1,892 | 5,000 | 18,925 |
| 750 | 2,839 | | |

occupancies by a minimum of 2-hour fire-rated construction or physically separated from the protected building by a minimum of 50 ft (15.3 m).

4.14.1.1.2* Except as permitted in 4.14.1.1.3, indoor fire pump rooms in non-high-rise buildings or in separate fire pump buildings shall be physically separated or protected by fire-rated construction in accordance with Table 4.14.1.1.2.

4.14.1.1.3* Fire pump units supplying a local application fire protection system(s) shall be physically separated from the hazard being protected in a manner that will prevent a fire associated with the hazard from directly exposing the pumping unit.

4.14.1.1.4 The location of and access to the fire pump room shall be preplanned with the fire department.

4.14.1.1.5* Except as permitted in 4.14.1.1.6, rooms containing fire pumps shall be fire from storage, equipment, and penetrations not essential to the operation of the pump and related components.

4.14.1.1.6* Equipment related to domestic water distribution shall be permitted to be located within the same room as the fire pump equipment.

4.14.1.1.7 The pump room or pump house shall be sized to fit all of the components necessary for the operation of the fire pump and to accommodate the following:

- (1) Clearance between components for installation and maintenance
- (2) Clearance between a component and the wall for installation and maintenance
- (3) Clearance between energized electrical equipment and other equipment in accordance with NFPA 70
- (4) Orientation of the pump to the suction piping to allow compliance with 4.16.6.3

4.14.1.2 Outdoor Fire Pump Units.

4.14.1.2.1 Fire pump units that are outdoors shall be located at least 50 ft (15.3 m) away from any buildings and other fire exposures.

4.14.1.2.2 Outdoor installations shall be required to be provided with protection against possible interruption in accordance with 4.14.1.

4.14.1.3 Fire Pump Buildings or Rooms with Diesel Engines. Fire pump buildings or rooms enclosing diesel engine pump drivers and day tanks shall be protected with an automatic sprinkler system installed in accordance with NFPA 13 as an Extra Hazard Group 2 occupancy.

Table 4.14.1.1.2 Equipment Protection

| Pump Room/ House | Building(s) Exposing Pump Room/House | Required Separation |
|--------------------------------------|---|---|
| Not sprinklered Fully sprinklered | Not sprinklered Fully sprinklered | 2 hour fire-rated or 50 ft (15.3 m) |
| Fully sprinklered | Fully sprinklered | 1 hour fire-rated or 50 ft (15.3 m) |

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

4.14.8 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*.

4.15 Pipe and Fittings.

4.15.1* Steel Pipe.

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

4.15.1.2 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.

4.15.1.3 Thick bituminous linings shall not be used.

4.15.2* Joining Method.

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

4.15.2.2 Slip-type fittings shall be permitted to be used where installed as required by 4.16.6 and where the piping is mechanically secured to prevent slippage.

4.15.2.3 The piping around check valves installed per 4.32.4.1, orifice unions, orifice plates, flowmeters, and other devices that have restricting orifices shall have a means to perform an internal inspection or a means to disassemble the piping to allow for the internal inspection of the restricting orifice(s).

4.15.3 Restricting Orifice Identification. Check valves installed per 4.32.4.1, orifice unions, orifice plates, and other devices with a restricting orifice shall have a permanent tag or other means of identification indicating that a restricting orifice is present.

4.15.4 Concentrate and Additive Piping.

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

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

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

4.15.6* Piping, Hangers, and Seismic Bracing.

4.15.6.1 The support of pipe and fittings shall comply with the requirements of Chapter 17 of NFPA 13.

4.15.6.2 The seismic protection, where applicable, of pipe and fittings shall comply with the requirements of Chapter 18 of NFPA 13.

4.15.7* 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.

4.16 Suction Pipe and Fittings.

4.16.1* Components.

4.16.1.1 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.

4.16.1.2 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.

4.16.2 Installation. Suction pipe shall be installed and tested in accordance with NFPA 24.

4.16.3* Suction Size.

4.16.3.1 Unless the requirements of 4.16.3.2 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 at the lowest permissible suction pressure, as discussed in 4.6.2.3.1), the gauge pressure at the pump suction flanges shall be 0 psi (0 bar) or higher.

4.16.3.2* The requirements of 4.16.3.1 shall 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) at 150 percent of rated flow with the lowest water level after the maximum system demand and duration have been supplied.

4.16.3.3 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 4.28.

4.16.4* Pumps with Bypass.

4.16.4.1 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.4.16.4.)

4.16.4.2 For multistage multipoint pumps, 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.4.16.4.)

4.16.4.3 The size of the bypass shall be at least as large as the pipe size required for discharge pipe as specified in Section 4.28.

4.16.5* Valves.

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

4.16.5.2 Valve Closure Time.

4.16.5.2.1 Listed indicating valves shall not close in less than 5 seconds when operated at maximum possible speed from the fully open position.

4.16.5.2.2 Valves with an automatic means to operate the valve shall not close in less than 5 seconds when operated at maximum possible speed from the fully open position.

- (5) A listed suction diffuser shall be permitted in the fire pump suction.
- (6) Other devices specifically permitted or required by this standard shall be permitted.

4.16.10* 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.

4.17 Discharge Pipe and Fittings

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

4.17.2 For multistage multipoint pumps, 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.

4.17.3 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.

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

4.17.5 All pump discharge pipe shall be hydrostatically tested in accordance with NFPA 13.

4.17.6* The size of pump discharge pipe and fittings shall not be less than that given in Section 4.28.

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

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

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

4.17.10 Low Suction Pressure Controls

4.17.10.1 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.

4.17.10.2 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.

4.17.10.3 The size of the suction pressure regulating valve shall not be less than that given for discharge piping in Section 4.28.

4.17.10.4 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.

4.17.10.5 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.

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

4.18* Valve Supervision

4.18.1 Supervised Open. Where provided, the suction valve, discharge valve, bypass valves, 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 at a constantly attended point
- (3) Locking valves open
- (4) Sealing of valves and approved weekly recorded inspection where valves are located within fenced enclosures under the control of the owner

4.18.2 Supervised Closed. Control valves located in the pipeline to the hose valve header shall be supervised closed by one of the methods allowed in 4.18.1.

4.19* 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.

4.19.1 Unless the requirements of 4.19.2 through 4.19.4 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.

4.19.2 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.

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

4.19.4 Where protection of piping against damage caused by earthquakes is required, the provisions of Section 4.30 shall apply.

4.19.5 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.

4.20 Relief Valves for Centrifugal Pumps

4.20.1* General

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

4.20.1.2 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.

4.20.1.3 Where an electric variable speed pump or a diesel pressure limiting driver 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.

4.20.1.3.1 Where an electric variable speed pump or diesel pressure limiting driver 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.

(2) The suction and discharge pressures from all pumps operating in series shall be displayed in all pump rooms housing the series fire pumps.

(3) The alarms and signals shall be annunciated in the other fire pump rooms for all pumps that are a part of the series fire pump unit in accordance with 4.21.2.8 and 4.21.2.9.

(4) The interconnect control wiring between the controllers in different pump rooms shall comply with 4.21.2.8 and 4.21.2.9.

(5) A pump room communication system that shall comply with 4.21.2.9 and 4.21.2.10.

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

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

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

4.21.2.6 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.

4.21.2.7 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.

4.21.2.8 Protection of Control Wiring for Series Fire Pump Units

4.21.2.8.1* 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.

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

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

4.21.2.9 Status Signals for Series Fire Pump Units

4.21.2.9.1 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.

4.21.2.9.1.1 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)

4.21.2.9.1.2 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)

4.21.2.9.2 Series fire pump controller(s) shall be provided with additional contacts for remote indication in accordance with 4.21.2.9.1.1 or 4.21.2.9.1.2.

4.21.2.9.2.1 Where other means are used to communicate this information, additional contacts in 4.21.2.9.2 shall not be required.

4.21.2.10 Communications for Series Fire Pump Units

4.21.2.10.1 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.

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

4.22 Water Flow Test Devices

4.22.1 General

4.22.1.1* 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.

4.22.1.2 Where multiple pumps are installed, it shall be permitted to manifold the fire pump test discharge piping to a common flow measuring device and discharge.

4.22.1.2.1 Where a single pump can supply the maximum fire protection system demand, the common piping, flow measuring device, and discharge shall be sized for the fire pump with the highest rated flow in accordance with 4.22.2 and 4.22.3.

4.22.1.2.2 Where multiple pumps arranged in series are required to meet the maximum fire protection system demand, the common piping, flow measuring device, and discharge shall be sized for the fire pump with the highest rated flow in accordance with 4.22.2 and 4.22.3.

4.22.1.2.3 Where multiple pumps arranged in parallel are required to operate simultaneously to meet the maximum fire protection system demand, the common piping, flow measuring device, and discharge shall be sized in accordance with 4.22.2 and 4.22.3 for the combined rated flow of all fire pumps required to operate simultaneously.

4.22.1.2.4 The common flow measuring device shall be capable of providing accurate flow measurements when testing a single fire pump and when simultaneously testing all fire pumps required to operate simultaneously.

4.22.1.2.5 A control valve shall be installed on each fire pump test connection upstream of the manifold.

4.22.1.3* 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.

4.22.1.4 The flow shall continue until the flow has stabilized. (See 4.2.2.6.6.)

4.22.1.5* 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.

4.22.2 Meters and Testing Devices.

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

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

4.22.2.3 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.

4.22.2.4 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 4.28.

4.22.2.5 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.

4.22.2.6 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.

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

4.22.2.8 The readout instrument shall be sized for the pump-rated capacity. (See Section 4.28.)

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

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

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

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

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

4.22.3 Hose Valves.

4.22.3.1* General.

4.22.3.1.1 Hose valves shall be listed.

4.22.3.1.2 The number and size of hose valves used for pump testing shall be as specified in Section 4.28.

4.22.3.1.3 Where outlets are being utilized as a means to test the fire pump in accordance with 4.22.1.1, one of the following methods shall be used:

- (1)* Hose valves mounted on a hose valve header with supply pipe sized in accordance with 4.22.3.1.4 and Section 4.28
- (2) Wall hydrants, yard hydrants, or sandpipe outlets of sufficient number and size to allow testing of the pump

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

- (1) Hose valve(s) shall have the NHT standard external thread for the valve size specified, as stipulated in NFPA 1963.
- (2) Where local fire department connections do not conform to NFPA 1963 and the connection is to be utilized as a wall hydrant, the authority having jurisdiction shall designate the threads to be used.

4.22.3.3 Location.

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

4.22.3.3.2 A drain valve or automatic ball drip 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.)

4.22.3.3.3 The valve required in 4.22.3.3.1 shall be at a point in the line close to the pump. (See Figure A.6.3.1(a).)

4.22.3.4 Pipe Size. The pipe size shall be in accordance with one of the following 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 4.22.3.1.3 shall be used.
- (2)* This pipe shall be permitted to be sized by hydraulic calculations that match the actual test configuration and for the total length of pipe and hose plus equivalent lengths of fittings, control valve, and hose valves, plus elevation loss, from the pump discharge flange to the discharge outlets.

4.22.3.4.1 In accordance with 4.22.3.4(2), the installation shall be proven by a test flowing the lesser of 150 percent of rated flow or the maximum flow available at the lowest permissible suction pressure to achieve the required pilot pressure or higher.

4.23 Steam Power Supply Dependability.

4.23.1 Steam Supply.

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

4.23.1.2 Consideration shall include the possible effect of interruption of transmission piping either on the property or in adjoining buildings that could threaten the property.

4.24 Shop Tests.

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

4.24.2 Preshipment Tests.

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

4.24.2.2 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 (17.24 bar).

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

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

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

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

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

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

4.27.1 For pressure-actuated 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 mist positive displacement pumping unit in accordance with 8.5.7.2
- (3) Another approved means that is not the main fire pump

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

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

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

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

4.27.5* Excess Pressure.

4.27.5.1 Where a centrifugal-type pressure maintenance pump has a total discharge pressure with the pump operating at shutoff 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 overpressuring of the system shall be installed on the pump discharge to prevent damage to the fire protection system.

4.27.5.2 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.

4.27.6 Piping and Components for Pressure Maintenance Pumps.

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

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

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

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

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

4.27.6.6 The pressure sensing line for the pressure maintenance pump shall be in accordance with Section 4.32.

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

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

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

4.27.9 The pressure maintenance pump shall not be required to have alternate or standby power.

4.28 Summary of Centrifugal Fire Pump Data. The sizes indicated in Table 4.28(a) and Table 4.28(b) shall be used as a minimum.

4.29 Backflow Preventers and Check Valves.

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

4.29.2 Relief Valve Drainage.

4.29.2.1 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.

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

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

4.29.2.4 Performance of the requirements in 4.29.2.1 through 4.29.2.3 shall be documented by engineering calculations and tests.

4.29.3 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.

4.29.3.1 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 4.16.5.4.

4.29.4 Evaluation.

4.29.4.1 Backflow Prevention Device.

4.29.4.1.1 Where a backflow prevention device or assembly is installed in connection with the pump, special consideration shall be given to the increased pressure loss resulting from the installation.

Table 4.28(a) Summary of Centrifugal Fire Pump Data (U.S. Customary)

| Pump Rating (gpm) | Minimum Pipe Sizes (Nominal) (in.) | | | | | | | | | |
|----------------------|---------------------------------------|--------|------------------------|-------|-------------------------|---------|--------------------|---------|--------------------|--------|
| | Suction ^{a,b,c} | | Discharge ^a | | Relief Valve | | Meter Device | | Number and Size of | |
| | Hose Valves | | Hose Valves | | Nonthreaded Connections | | Hose Header Supply | | | |
| 25 | 1 | 1 | 3/4 | 1 | 1-1/2 | 1-2 1/2 | 1 1/2 | 1-2 1/2 | 1 | 1 |
| 50 | 1 1/2 | 1 1/2 | 1 1/4 | 1 1/2 | 1-1/2 | 1-2 1/2 | 1 1/2 | 1-2 1/2 | 1 1/2 | 1 1/2 |
| 100 | 2 | 2 | 1 1/4 | 2 | 1-2 1/2 | 1-2 1/2 | 2 1/2 | 1-2 1/2 | 2 1/2 | 2 1/2 |
| 150 | 2 1/2 | 2 1/2 | 2 | 2 1/2 | 1-2 1/2 | 1-2 1/2 | 3 | 1-2 1/2 | 3 | 3 |
| 200 | 3 | 3 | 2 | 2 1/2 | 1-2 1/2 | 1-2 1/2 | 3 1/2 | 1-2 1/2 | 3 1/2 | 3 1/2 |
| 250 | 3 1/2 | 3 | 2 1/2 | 2 1/2 | 1-2 1/2 | 1-2 1/2 | 3 1/2 | 1-2 1/2 | 3 1/2 | 3 1/2 |
| 300 | 4 | 4 | 2 1/2 | 2 1/2 | 1-2 1/2 | 1-2 1/2 | 4 | 1-2 1/2 | 4 | 4 |
| 400 | 4 1/2 | 4 1/2 | 3 | 3 | 2-2 1/2 | 1-5 | 4 1/2 | 1-5 | 4 1/2 | 4 1/2 |
| 450 | 5 | 5 | 3 | 3 | 2-2 1/2 | 1-5 | 5 | 1-5 | 5 | 5 |
| 500 | 5 1/2 | 5 1/2 | 3 1/2 | 3 1/2 | 2-2 1/2 | 1-5 | 5 1/2 | 1-5 | 5 1/2 | 5 1/2 |
| 750 | 6 | 6 | 4 | 4 | 3-2 1/2 | 1-5 | 6 | 1-5 | 6 | 6 |
| 1000 | 8 | 8 | 4 1/2 | 4 1/2 | 4-2 1/2 | 1-5 | 8 | 1-5 | 8 | 8 |
| 1250 | 8 1/2 | 8 1/2 | 5 | 5 | 4-2 1/2 | 1-5 | 8 1/2 | 1-5 | 8 1/2 | 8 1/2 |
| 1500 | 9 | 9 | 5 1/2 | 5 1/2 | 4-2 1/2 | 1-5 | 9 | 1-5 | 9 | 9 |
| 2000 | 10 | 10 | 6 | 6 | 6-2 1/2 | 2-5 1/2 | 10 | 2-5 1/2 | 10 | 10 |
| 2500 | 10 1/2 | 10 1/2 | 6 1/2 | 6 1/2 | 8-2 1/2 | 2-5 1/2 | 10 1/2 | 2-5 1/2 | 10 1/2 | 10 1/2 |
| 3000 | 12 | 12 | 8 | 8 | 12-2 1/2 | 2-5 1/2 | 12 | 2-5 1/2 | 12 | 12 |
| 3500 | 12 1/2 | 12 1/2 | 8 1/2 | 8 1/2 | 12-2 1/2 | 3-5 1/2 | 12 1/2 | 3-5 1/2 | 12 1/2 | 12 1/2 |
| 4000 | 14 | 14 | 10 | 10 | 16-2 1/2 | 3-5 1/2 | 14 | 3-5 1/2 | 14 | 14 |
| 4500 | 16 | 16 | 12 | 12 | 16-2 1/2 | 3-5 1/2 | 16 | 3-5 1/2 | 16 | 16 |
| 5000 | 16 1/2 | 16 1/2 | 14 | 14 | 20-2 1/2 | 3-5 1/2 | 16 1/2 | 3-5 1/2 | 16 1/2 | 16 1/2 |

Notes:

(1) The pressure relief valve is permitted to be sized in accordance with 4.20.2.1.

(2) The pressure relief valve discharge is permitted to be sized in accordance with 4.20.2.2.

(3) The flowmeter device is permitted to be sized in accordance with 4.22.2.3.

(4) The hose header supply is permitted to be sized in accordance with 4.22.3.1.

(5) Other types of test outlets, sizes, and quantities are permitted when approved by the authority having jurisdiction.

^aActual diameter of pump flange is permitted to be different from pipe diameter.^bApplies only to that portion of suction pipe specified in 4.16.3.3.^cSuction pipe sizes in Table 4.28(a) are based on a maximum velocity at 150 percent rated capacity to 15 ft/sec (4.6 m/sec) in most cases.^dProvide a control valve on each outlet where more than one nonthreaded connection is required.

4.29.4.1.2 Where a backflow prevention device is installed, the final arrangement shall provide effective pump performance at the lowest permissible suction pressure.

4.29.4.1.3 The discharge flow rate shall meet or exceed the fire protection system design flow.

4.29.4.1.4 The discharge flow rate shall meet or exceed 100 percent of the fire pump rated flow rate.

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

4.29.4.1.6 Retroactive 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.

4.29.4.1.7 Retroactive installation of a backflow prevention device shall not result in a discharge pressure that does not meet the maximum system demand and 100 percent of the rated flow rate for the fire pump.

4.30 Earthquake Protection.

4.30.1 General. Where water-based fire protection systems to be protected against damage from earthquakes, 4.30.2 and 4.30.3 shall apply.

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

4.30.3 Components.

4.30.3.1 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.

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

Table 4.28(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 | | Meter Device | | Number and Size of | |
| | Hose Valves | | Hose Valves | | Nonthreaded Connections | | Hose Header Supply | | | |
| 95 | 25 | 25 | 19 | 25 | 32 | 32 | 32 | 1-38 | 1-65 | 25 |
| 189 | 38 | 32 | 32 | 38 | 50 | 38 | 38 | 1-38 | 1-65 | 38 |
| 379 | 50 | 50 | 38 | 50 | 65 | 50 | 50 | 1-65 | 1-65 | 65 |
| 568 | 65 | 65 | 50 | 65 | 75 | 65 | 65 | 1-65 | 1-65 | 65 |
| 757 | 75 | 75 | 50 | 75 | 75 | 75 | 75 | 1-65 | 1-65 | 65 |
| 946 | 85 | 75 | 50 | 75 | 85 | 85 | 85 | 1-65 | 1-65 | 75 |
| 1,136 | 100 | 100 | 65 | 85 | 85 | 85 | 85 | 1-65 | 1-65 | 75 |
| 1,514 | 100 | 100 | 75 | 125 | 100 | 100 | 100 | 2-65 | 1-125 | 100 |
| 1,703 | 125 | 125 | 75 | 125 | 125 | 125 | 125 | 2-65 | 1-125 | 100 |
| 1,892 | 125 | 125 | 75 | 125 | 125 | 125 | 125 | 2-65 | 1-125 | 100 |
| 2,839 | 150 | 150 | 100 | 150 | 125 | 125 | 125 | 3-65 | 1-125 | 150 |
| 3,785 | 200 | 150 | 100 | 200 | 150 | 150 | 150 | 4-65 | 1-125 | 150 |
| 4,731 | 200 | 200 | 150 | 200 | 200 | 200 | 200 | 6-65 | 1-125 | 200 |
| 5,677 | 200 | 200 | 150 | 200 | 200 | 200 | 200 | 6-65 | 1-125 | 200 |
| 7,570 | 250 | 250 | 150 | 250 | 200 | 200 | 200 | 6-65 | 2-125 ^d | 200 |
| 9,462 | 250 | 250 | 150 | 250 | 200 | 200 | 200 | 8-65 | 2-125 ^d | 250 |
| 11,355 | 300 | 300 | 200 | 300 | 200 | 200 | 200 | 12-65 | 2-125 ^d | 250 |
| 13,247 | 300 | 300 | 200 | 300 | 250 | 250 | 250 | 12-65 | 3-125 ^d | 300 |
| 15,140 | 350 | 300 | 200 | 350 | 250 | 250 | 250 | 16-65 | 3-125 ^d | 300 |
| 17,032 | 400 | 350 | 200 | 350 | 250 | 250 | 250 | 16-65 | 3-125 ^d | 300 |
| 18,925 | 400 | 350 | 200 | 350 | 250 | 250 | 250 | 20-65 | 3-125 ^d | 300 |

Notes:

(1) The pressure relief valve is permitted to be sized in accordance with 4.20.2.1.

(2) The pressure relief valve discharge is permitted to be sized in accordance with 4.20.2.2.

(3) The flowmeter device is permitted to be sized in accordance with 4.22.2.3.

(4) The hose header supply is permitted to be sized in accordance with 4.22.3.1.

(5) Other types of test outlets are permitted when approved by the authority having jurisdiction.

^aActual diameter of pump flange is permitted to be different from pipe diameter.^bApplies only to that portion of suction pipe specified in 4.16.3.3.^cSuction pipe sizes in Table 4.28(b) are based on a maximum velocity at 150 percent rated capacity to 15 ft/sec (4.6 m/sec) in most cases.^dProvide a control valve on each outlet where more than one nonthreaded connection is required.

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

4.30.3.4 Appurtenances. Seismic protection of appurtenances, including trim pieces, shall be required where they are essential for post-earthquake operation of the fire pump.

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

4.31 Packaged Fire Pump Assemblies.

4.31.1 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.

(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 D1.1/D1.1M, *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.

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

4.31.3 Packaged and prefabricated skid unit(s) shall meet all the requirements in this standard, including those described in Sections 4.1.4 through 4.1.9.

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

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

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 float-operated air release valve having a nominal 0.50 in. (12.7 mm) minimum diameter discharged to atmosphere.

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

6.4 Foundation and Setting.

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

6.4.2 Pumps of the overhauling 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 shaft 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 ANSI/HI 1.4, *Rotodynamic Centrifugal Pumps for Manual Drilling Installation, Operation and Maintenance*, (See A.6.5.1)

Chapter 7 Vertical Shaft Turbine-Type Pumps

7.1* General.

7.1.1* **Application.** Where the water supply is located below the discharge flange 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 A.6.2.)

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.

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 (3.2 m) below the pumping water level at 150 percent of rated capacity. (See Figure A.7.2.2.1.)

7.2.2.1.3* The submergence shall be increased by 1 ft (0.3 m) for each 1000 ft (305 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. (305 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 ample diameter and sufficiently plumb 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 be studded 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 meets 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-rounded 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 an 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 unconsolidated formations above the rock, surface casing shall be installed, seated 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 ppm) 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.

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, bowl assembly, maximum down thrust, and the oil tube 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 threads to permit the ends to butt so as to form accurate alignment of the pump column.

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 (Plain Ends) (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 (Plain Ends) (kg/m) |
|-------------------|------------------------------|--|
| 150 | 161 | 28.230 |
| 200 | 212 | 36.758 |
| 250 | 264 | 46.431 |
| 300 | 315 | 65.137 |
| 350 | 360 | 81.209 |

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

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.)

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

7.3.2.7 The pump fireshafting 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 rated 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 Suction 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.)

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 4.12.1
- (4) Relief valve and discharge cone where required by 4.20.1
- (5) Hose valve header and hose valves as specified in 4.22.3 or metering devices as specified in 4.22.2

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 4.14 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.

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, its 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 15,000 hours.

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 nonreverse inset shaft.

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 vertical turbine pumps using right-angle gear drives driven by a diesel engine, a listed torsional coupling shall be used and mounted on the engine side of the driveshaft.

7.5.1.6.1.1 For drive systems that include a diesel engine, torsional coupling, right-angle gear drive, and vertical shaft pump, the pump manufacturer shall provide, at a minimum, a 3-mass torsional frequency calculation, indicating that the first

two natural frequencies of the system and the critical speeds associated with engine firing frequency are found to be no less than 25 percent above or below when the pump is operating at rated speed.

7.5.1.6.1.2* The torsional frequency calculation specified in 7.5.1.6.1.1 shall include the mass elastic characteristics for a wetted pump with the specific impeller(s) trim, torsional coupling, right-angle gear, gear ratio, flexible connecting shaft, and the engine.

7.5.1.6.1.3* Where the calculations required in 7.5.1.6.1.1 indicate that critical speeds are found to fall less than 25 percent above or below pump rated speed, a further detailed set of forced response calculations shall be required for the vertical and horizontal components indicating there are no damaging vibratory stresses or torques.

7.5.1.6.1.4* The torsional analysis specified in 7.5.1.6.1.3 shall include the mass elastic characteristics required in 7.5.1.6.1.2 plus the following:

- (1) The excitation characteristics of the specific engine and rating
- (2) A fully flexible lumped parameter model having multiple elements along the length of the engine crankshaft, the horizontal shafting, and vertical shafting to all pump stages
- (3) The effect of engine misfire

7.5.1.6.1.5 For a system defined in 7.5.1.6.1 that uses a variable speed diesel driver, the operating speed for the analytical speeds shall be defined as not less than 25 percent above the pump rated speed and not less than 25 percent below the lowest possible speed of the variable speed driver.

7.5.1.6.1.6 The torsional coupling required in 7.5.1.6.1 shall be permitted to be omitted when a complete mass elastic system torsional analysis is provided and accepted by the authority having jurisdiction and indicates that the system meets the requirements of 7.5.1.6.1.3 without a torsional coupling being included in the system.

7.5.1.6.1.7* In addition to the requirements of 7.5.1.6.1.3, results shall include engine critical response, crankshaft stress, and crankshaft damper heat dissipation.

7.5.1.6.2 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 less than 25 percent above or below the operating speed of the pump and driver.

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 coupling shall be used and mounted on the engine side of the driver shaft.

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

- (2) The safety relief valve and pump driver are sized to accommodate the back pressure in the pump suction.

8.5.5* Suction Strainer.

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.

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 Suction 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 ANSI/AGMA 2011-B14, *Cylindrical Wrengearing Tolerances 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 8.4 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 timing gear type 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 excepting 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.

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 9.4.

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.

9.1.8.3 Arc-resistant equipment shall be permitted.

9.2* Normal Power.

9.2.1 An electric motor-driven fire pump shall be provided with a normal source of power as a continually 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-style 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 service 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 owner, 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(3) 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 alternative source of power shall be provided for high-rise buildings.

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:

- (1) A generator installed in accordance with Section 9.6
- (2) One of the sources identified in 9.2.2(1), 9.2.2(2), 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 de-energized for fire department operations.

9.3.6 Two or More Alternate Sources.

9.3.6.1 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, overcurrent 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.

9.3.6.2 Protective devices shall not be installed in the load side of the power transfer switch.

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 motorstarting conditions.

9.4.2 The requirements of 9.4.1 shall not apply to emergency-run mechanical starting, provided a successful start can be demonstrated on the standby generator system. (See 10.5.3.2.)

9.4.2.1* The requirements of 9.4.1 shall apply to the emergency-run mechanical control of the self-regulating variable speed fire pump unit.

9.4.3 The requirements of 9.4.1 shall not apply to the bypass mode of a variable speed pressure limiting controller (see 10.10.5), provided a successful start can be demonstrated on the standby genset.

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 LFNC-B, 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 type¹ 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).)

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 230 V at 60 Hertz (A)* | Motor Designation (NTPA 70, Locked Rotor Indicating Code Letter) "P" to and Including |
|------------------|---|---|
| 1 | 30 | N |
| 1½ | 40 | M |
| 2 | 50 | L |
| 3 | 64 | K |
| 5 | 92 | J |
| 7½ | 127 | H |
| 10 | 162 | G |
| 15 | 232 | F |
| 20 | 290 | E |
| 25 | 365 | D |
| 30 | 435 | C |
| 40 | 580 | B |
| 50 | 725 | A |
| 60 | 870 | G |
| 75 | 1085 | F |
| 100 | 1450 | E |
| 125 | 1815 | D |
| 150 | 2170 | C |
| 200 | 2900 | B |
| 250 | 3650 | A |
| 300 | 4400 | G |
| 350 | 5100 | F |
| 400 | 5800 | E |
| 450 | 6500 | D |
| 500 | 7250 | C |

*Locked rotor current values are maximums.

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

9.5.1.1.2 International Electrotechnical Commission (IEC) motors, where used, shall be listed for fire service.

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.

9.5.1.3 Partwinding motors shall have a 50:50 winding ratio in order to have equal currents in both windings while running at nominal speed.

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

| Rated Horsepower | Locked Rotor Current Single-Phase 115 V at 60 Hertz (A)* | Design N | Design L |
|------------------|--|----------|----------|
| ¼ | 20 | — | 12 |
| ½ | 26 | — | 15 |
| ¾ | 31 | — | 18 |
| 1 | 35 | — | 20 |
| 1½ | 45 | — | 25 |
| 2 | 55 | — | 30 |
| 3 | 61 | — | 35 |
| 4 | 68 | — | 40 |
| 5 | 75 | — | 45 |
| 7½ | 80 | — | 50 |
| 10 | — | — | 65 |
| 15 | — | — | 90 |
| 20 | — | — | 135 |
| 25 | — | — | 200 |
| 30 | — | — | 260 |

*Locked rotor current values are maximums.

Table 9.5.1.1(c) Horsepower and Locked Rotor Current Motor Designation for Three-Phase, 380 V, 50 Hertz, NEMA Design B Motors

| Rated Horsepower | Locked Rotor Current Three-Phase 380 V at 50 Hertz (A)* | Motor Designation (NTPA 70, Locked Rotor Indicating Code Letter) "P" to and Including |
|------------------|---|---|
| 1 | 20 | P |
| 1½ | 27 | N |
| 2 | 34 | M |
| 3 | 43 | L |
| 5 | 61 | K |
| 7½ | 84 | J |
| 10 | 107 | H |
| 15 | 154 | G |
| 20 | 194 | F |
| 25 | 243 | E |
| 30 | 289 | D |
| 40 | 387 | C |
| 50 | 482 | B |
| 60 | 578 | A |
| 75 | 722 | H |
| 100 | 965 | G |
| 125 | 1207 | F |
| 150 | 1441 | E |
| 200 | 1927 | D |
| 250 | 2534 | C |
| 300 | 3026 | B |
| 350 | 3542 | A |
| 400 | 4046 | H |
| 450 | 4539 | G |
| 500 | 5089 | F |

*Locked rotor current values are maximums.

9.5.1.4* Motors Used with Variable Speed Controllers.

9.5.1.4.1 Motors shall meet the applicable requirements 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 460 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 460 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 10.4.3.3 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 dripproof, 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 used shall be as marked on the motor, but in no case exceed 1.15.

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 dripproof) 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

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 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 1000 ft (300 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 driver, 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 sub shaft, or a torsional coupling to the engine flywheel. (See Section 6.5 and 7.5.1.4.)

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 Mechanical fuel injection engines with a mechanical governor speed control device shall be allowed to employ an electric-actuated speed control override system to achieve speed control of less than 10 percent, provided the requirements of 11.2.4.1.1 are still met in the event that any component of the electric actuator speed control system fails.

11.2.4.1.4 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.

11.2.4.2.3.4 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.

11.2.4.2.3.5 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.

Shaded text = Revisions. Δ = Text deletions and figure/table revisions. * = Section deletions. Δ = New material.

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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.

11.2.4.3.2 Variable speed control systems shall not replace the engine governor as defined in 11.2.4.1.

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 11.2.4.1.

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 $\frac{1}{8}$ 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 drop-down 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 low 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 12.4.1.4.

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 12.4.1.5.

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.

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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 ac 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 11.2.4.2.6.

11.2.6 Wiring Elements.

11.2.6.1 Automatic Controller Wiring in Factory.

11.2.6.1.1* All connecting wires for automatic controllers shall be harnessed 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.

11.2.6.1.2 All wiring on the engine, including starting circuitry, shall be sized on a continuous-duty basis.

11.2.6.1.3 Provisions shall be made on the engine for connecting two remote sensing leads from each of the battery chargers for the purpose of accurately measuring the voltage across each of the battery terminals under all load conditions.

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.

11.2.6.2.1.1 Interconnection wire size shall be based on length as recommended for each terminal by the controller manufacturer.

11.2.6.2.2 The dc interconnections between the automatic controller and engine junction box and any ac 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 Starting 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 Engine Batteries.

11.2.7.2.1.1 Each engine shall be provided with two storage battery units: battery unit A and battery unit B.

11.2.7.2.1.2* Flooded lead-acid batteries shall be furnished in a moist or dry charge condition with electrolyte liquid in a separate container. Valve-regulated lead-acid (VRLA) batteries shall be furnished in a completed, charged condition.

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 11.2.7.2.5.3 are coordinated to meet the requirements of the specific batteries.

11.2.7.2.1.4* At 40°F (4°C), battery unit A shall have the capacity sufficient to maintain the cranking speed recommended by the engine manufacturer during six consecutive cycles of 15 seconds of cranking and 15 seconds of rest.

11.2.7.2.1.5 At 40°F (4°C), battery unit B shall have the capacity sufficient to maintain the cranking speed recommended by the engine manufacturer during six consecutive cycles of 15 seconds of cranking and 15 seconds of rest.

11.2.7.2.1.6* Battery unit A and battery unit B, combined, 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 six consecutive cycles of 15 seconds of cranking and 15 seconds of rest, without ac 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 contactor installed between each battery and the cranking motor for battery isolation.

(A) Main battery contactors shall be listed for fire pump driver service.

(B) Main battery contactors shall be rated for the cranking motor current.

(C) Main battery contactors shall be capable of manual mechanical operation, including positive methods such as spring-loaded, over-center operator 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

cal 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 ampere 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.

11.2.7.2.5* Battery Recharging.

11.2.7.2.5.1 Two means for recharging storage batteries shall be provided.

11.2.7.2.5.2 One method shall be the generator or alternator furnished with the engine.

11.2.7.2.5.3 The other method shall be an automatically controlled battery charger, in accordance with Section 12.6, taking power from an ac power source.

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 piping between the engine and the hydraulic accumulator system shall be installed in accordance with the manufacturer's maximum allowed pressure drop recommendations.

11.2.7.3.3 The diesel engine as installed shall be without starting aid except that as required in 11.2.8.2.

11.2.7.3.4 The diesel engine 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 The hydraulic cranking system 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.

11.2.7.3.6 Electrically operated means or air operated means shall automatically recharge and maintain the stored hydraulic pressure to the predetermined pressure requirements.

11.2.7.3.7 The means of automatically maintaining the hydraulic system within the predetermined pressure require-

ments shall be energized from the main bus and the final emergency bus if one is provided.

11.2.7.3.8 Engine driven means shall be provided to recharge the hydraulic system when the engine is running.

11.2.7.3.9 Means shall be provided to manually recharge, bleed, and purge the hydraulic accumulator system.

11.2.7.3.10 When the engine is equipped with multiple cranking systems (of different types), one system shall be defined as a primary cranking system and the other as a secondary cranking system.

11.2.7.3.11 When used as the only or primary cranking system, the capacity of the hydraulic cranking system shall provide not fewer than twelve cranking cycles of not less than 15 seconds each (capacity for 180 seconds of total crank time).

11.2.7.3.11.1 The total capacity shall be provided from two separate, equally sized accumulator systems.

11.2.7.3.11.2 The first six attempts shall be automatic from the signaling source, alternating between accumulator systems.

11.2.7.3.11.3 The second six attempts shall be manually activated from either engine or controller, with each button-push initiating a complete 15-second crank attempt.

11.2.7.3.12 When used as a secondary cranking system, the capacity of the hydraulic cranking system shall be capable of providing not fewer than six cranking cycles of not less than 15 seconds each (capacity for 90 seconds of total crank time).

11.2.7.3.12.1 The first three attempts shall be automatic from the signaling source.

11.2.7.3.12.2 The second three attempts are to be manually activated from either engine or controller, with each button-push initiating a complete 15-second crank attempt.

11.2.7.3.13 For primary and secondary cranking systems, each cranking cycle 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).

11.2.7.3.14 All controls for engine shutdown in the event of overspeed shall be 12 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 re-cranking.

(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 conductors for automatic controllers shall be harnessed 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 Where the engine is equipped with multiple cranking systems of different types, one system shall be defined as a primary cranking system and the other as a secondary cranking system.

11.2.7.4.4.2 Where used as the only or primary cranking system, the air supply container shall be sized for 180 seconds of continuous cranking without recharging.

11.2.7.4.4.3 Where used as the only or primary cranking system, the total capacity shall be provided from two separate, equally sized air supply containers A and B.

11.2.7.4.4.4 Where used as the only or primary cranking system, the first start attempt shall be automatic from the signaling source, pulling from air supply container A with 90 seconds of crank duration.

11.2.7.4.4.5 Where used as the only or primary cranking system, the second start attempt shall be manually activated from either engine or controller, pulling from air supply container B and only cranking while the button is held in.

11.2.7.4.4.6 Where used as a secondary cranking system, the air supply container shall be sized for 90 seconds of continuous cranking without recharging.

11.2.7.4.4.7 Where used as a secondary cranking system, the first start attempt shall be automatic from the signaling source with 45 seconds of crank duration.

11.2.7.4.4.8 Where used as a secondary cranking system, the second start attempt shall be manually activated from either engine or controller; only cranking while the button is held in.

11.2.7.4.4.9 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.

11.2.7.4.4.10 Suitable supervisory service shall be maintained to indicate high and low air pressure conditions.

11.2.7.4.4.11 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

lating 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 make-up 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 15540. *For Resistance of Non-Metallic Hose Assemblies and Non-Metallic Compensators — Test Methods.*

11.2.8.5.3.3 The pipe connection in the direction of flow shall include an indicating manual shutoff valve, an approved flushing-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 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 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 150 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 spring-loaded check valves or backflow preventers shall be installed.

(A)* The spring-loaded 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 flushing-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 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.

11.2.8.7 Heat Exchanger Waste Outlet.

11.2.8.7.1 An outlet shall be provided for the wastewater line from the heat exchanger, and the discharge line shall be less than one size larger than the inlet line.

11.2.8.7.2 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.

11.2.8.7.3 The outlet shall be permitted to discharge to a suction reservoir, provided a visual flow indicator and temperature indicator are installed.

11.2.8.7.4 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.

11.2.8.8 Radiators.

11.2.8.8.1 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.

11.2.8.8.2 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.

11.2.8.8.3 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 ventilator.

11.2.8.8.4 Fan.

11.2.8.8.4.1 The fan shall push the air through the radiator to be exhausted from the room via the air discharge ventilator.

11.2.8.8.4.2 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 ventilators in addition to the radiator, fan guard, and other engine component obstructions.

11.2.8.8.4.3 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
- (4) 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 tank(s) 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 sump.

11.4.1.3.2 Whether larger-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 142, *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 (4990 L).

11.4.1.4.3.1 For situations where fuel tanks in excess of 1320 gal (4990 L) are being used, the requirements of NFPA 57 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 142, *Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids*, or other approved standards.

⚠ (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. (32 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.

11.4.1.5.6.1 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 fuel leakage and annunciated by the engine drive controller.

ⓘ 11.4.1.5.9 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 indication 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.

11.4.3* Fuel Supply Tank Location.

11.4.3.1 Diesel fuel supply tanks shall be located above ground in accordance with municipal or other ordinances and in accordance with requirements of the authority having jurisdiction and shall not be buried.

11.4.3.2 In zones where freezing temperatures [32°F (0°C)] are possible, the fuel supply tanks shall be located in the pump room.

11.4.3.3 The supply tank shall be located so the fuel supply pipe connection to the engine is no lower than the level of the engine fuel transfer pump.

11.4.3.4 The engine manufacturer's fuel pump static head pressure limits shall not be exceeded when the level of fuel in the tank is at a maximum.

11.4.4* Fuel Piping.

11.4.4.1 Flame-resistant reinforced flexible hose with a 30 minute fire resistance rating equal to ISO 15540, *Fire Resistance of Non-Metallic Hose Assemblies and Non-Metallic Compensators*, *Test Methods*, and a pressure rating no less than 2 times the fuel supply and return working pressure with threaded connections shall be provided at the engine for connection to fuel system piping.

11.4.4.2 Fuel piping shall not be galvanized steel or copper.

11.4.4.2.1 Where black steel pipe is used for fuel piping, the fittings shall be steel or malleable iron fittings.

11.4.4.3 The fuel return line shall be installed according to the engine manufacturer's recommendation.

11.4.4.3.1 A check valve, as specified by the engine manufacturer, shall be permitted to be installed in the fuel return line only when required by the engine manufacturer.

11.4.4.4 There shall be no shutoff valve in the fuel return line to the tank.

11.4.4.5 A manual shut off valve shall be provided within the tank fuel supply line.

11.4.4.5.1 The valve shall be locked in the open position.

11.4.4.5.2 No other valve than a manual locked open valve shall be put in the fuel line from the fuel tank to the engine except as provided as part of the fitted engine.

11.4.4.6* Fuel Line Protection. A guard, pipe protection, or approved double-walled pipe shall be provided for all fuel lines exposed to traffic or possible damage.

11.4.4.7* Fuel Solenoid Valve. Where an electric solenoid valve is used to control the engine fuel supply, it shall be capable of manual mechanical operation or of being manually bypassed in the event of a control circuit failure.

11.4.5* Fuel Type.

11.4.5.1* The type and grade of diesel fuel shall be as specified by the engine manufacturer.

11.4.5.2 In areas where local air quality management regulations allow only the use of DF #1 fuel and no diesel fire pump driver is available listed for use with DF #1 fuel, an engine listed for use with DF #2 shall be permitted to be used but shall have the nameplate rated horsepower derated 10 percent, provided the engine manufacturer approves the use of DF #1 fuel.

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 ignitions.

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 Engine Exhaust.

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 burned 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 Backpressure 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 end-user 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 and Article 505 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 control shall be permitted to run at reduced speeds provided factory-set 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.

11.6.3.6.1 This inspection shall determine that the charger is operating correctly, the water level in the battery is correct, and the battery is holding its proper charge.

11.6.4 Fuel Supply Maintenance.

11.6.4.1 The fuel storage tanks shall be designed and installed so that they can be kept as full and maintained as practical at all times but never below 66 percent (two-thirds) of tank capacity.

11.6.4.2 The tanks shall be designed and installed so that they can always be filled by means that will ensure removal of all water and foreign material.

11.6.4.3* The tanks shall be designed and installed so that they can be maintained by means that will ensure removal of water and foreign material.

11.6.4.4* An active fuel maintenance system listed for fire pump service shall be permitted to be installed for the maintenance of the fuel in the supply tank.

11.6.4.4.1 Where provided, the active fuel maintenance system shall be equipped with a visible indicator to indicate when the system is in need of maintenance.

11.6.4.4.2 Where provided, the active fuel maintenance system shall be equipped with a contact closure for signaling to the controller when the system is in need of maintenance.

11.6.4.4.3 Where provided, the active fuel maintenance systems shall be permanently connected to the fuel tank as follows:

- (1) All connections shall be made directly to the tank.
- (2) The supply from the tank to the active fuel maintenance system shall include a manual shutoff valve and a connection to the drain located between the bottom of the tank and the drain valve of the fuel storage tank.
- (3) The return from the active fuel maintenance system to the fuel storage tank shall be connected to the dedicated connection on the top of the tank with a drop tube down to the 50 percent level, and shall include a manual shutoff valve for servicing the system.

11.6.5 Temperature Maintenance.

11.6.5.1 The temperature of the pump room, pump house, or area where engines are installed shall be designed so that the temperature is maintained at or above the minimum recommended by the engine manufacturer.

11.6.5.2 In locations where electrical power is not reliable and where there is a risk of pump room freezing, an alternate power source shall be provided to maintain space heating, battery charging, engine block heating, and lighting.

11.6.6 Emergency Starting and Stopping.

11.6.6.1 The sequence for emergency manual operation, arranged in a step-by-step manner, shall be posted on the fire pump engine.

11.6.6.2 It shall be the engine manufacturer's responsibility to list any specific instructions pertaining to the operation of this equipment during the emergency operation.

Chapter 12 Engine Drive Controllers

12.1 Application.

12.1.1 This chapter provides requirements for minimum performance of automatic/nonautomatic 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.

12.3.3 Enclosures.

12.3.3.1 Mounting.

12.3.3.1.1 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.

12.3.3.1.2 Where the equipment is located outside or special environments exist, suitably rated enclosures shall be used.

12.3.3.2 **Grounding.** The enclosures shall be grounded in accordance with NFPA 70, Article 250.

12.3.4 **Locked Lockable Cabinet.** All switches required to keep the controller in the automatic position shall be within locked enclosures having breakable glass panels.

12.3.5 Connections and Wiring.**12.3.5.1 Field Wiring.**

12.3.5.1.1 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.

12.3.5.1.2 Such wiring shall be protected against mechanical injury.

12.3.5.1.3 Controller manufacturer's specifications for distance and wire size shall be followed.

12.3.5.2 **Wiring Elements.** Wiring elements of the controller shall be designed on a continuous-duty basis.

12.3.5.3 Field Connections.

12.3.5.3.1 A diesel engine fire pump controller shall not be used as a junction box to supply other equipment.

12.3.5.3.2 No external contacts or changes to the controller that interfere with the operation of the controller shall be installed.

12.3.5.3.3 Electrical supply conductors for pressure maintenance (jockey or make-up) pump(s) shall not be connected to the diesel engine fire pump controller.

12.3.5.3.3.1 Except as provided in 4.21.2.2, remote shutdown or interlock to prevent normal operation shall not be permitted unless approved by the authority having jurisdiction.

12.3.5.3.4 Diesel engine fire pump controllers shall be permitted to supply essential and necessary ac or dc power, or both, to operate pump room dampers and engine oil heaters and other associated required engine equipment only when provided with factory-equipped dedicated field terminals and overcurrent protection.

12.3.6 Electrical Diagrams and Instructions.

12.3.6.1 A field connection diagram shall be provided and permanently attached to the inside of the enclosure.

12.3.6.2 The field connection terminals shall be plainly marked to correspond with the field connection diagram furnished.

12.3.6.3 For external engine connections, the field connection terminals shall be commonly numbered between the controller and the engine terminals.

12.3.6.4 The installation instructions of the manufacturer of the fire pump controller shall be followed.

12.3.7 Marking.

12.3.7.1 Each operating component of the controller shall be plainly marked with the identification symbol that appears on the electrical schematic diagram.

12.3.7.2 The markings shall be located so as to be visible after installation.

12.3.8 **Instructions.** Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

12.4 Components.**12.4.1 Indicators on Controller.**

12.4.1.1 All visible indicators shall be plainly visible.

12.4.1.2* Visible indicators 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.

12.4.1.3 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 overspeed
- (5) High cooling water temperature

12.4.1.4 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 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).
- (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.

12.4.1.5 A separate signal silencing switch or valve, other than the controller main switch, shall be provided for the conditions reflected in 12.4.1.3 and 12.4.1.4.

12.4.1.5.1 The switch or valve shall allow the audible device to be silenced for up to 4 hours and then re-sound repeatedly for the conditions in 12.4.1.3.

12.4.1.5.2 The switch or valve shall allow the audible device to be silenced for up to 24 hours and then re-sound repeatedly for the conditions in 12.4.1.4.

12.4.1.5.3 The audible device shall re-sound until the condition is corrected or the main switch is placed in the off position.

12.4.1.6* The controller shall automatically return to the nonsilenced state when the alarm(s) have cleared (returned to normal).

12.4.1.7 Where audible signals for the additional conditions listed in A.4.26 are incorporated with the engine fire pump alarms specified in 12.4.1.3, a silencing switch or valve for the additional A.4.26 audible signals shall be provided at the controller.

12.4.1.8 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.

12.4.2 Signal Devices Remote from Controller.

12.4.2.1 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.

12.4.2.2 **Remote Indication.** Controllers shall be equipped to operate circuits for remote indication of the conditions covered in 12.4.1.3, 12.4.1.4, and 12.4.2.3.

12.4.2.3 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 signals). (See 12.4.1.4 and 12.4.1.5.)

12.4.3 **Controller Contacts for Remote Indication.** Controllers shall be equipped with open or closed contacts to operate circuits for the conditions covered in 12.4.2.

12.4.4* Pressure Recorder.

12.4.4.1 A listed pressure recording device shall be installed to sense and record the pressure in each fire pump controller pressure-sensing line at the input to the controller.

12.4.4.2 The recorder shall be capable of operating for at least 7 days without being reset or rewound.

12.4.4.3 The pressure-sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least 400 psi (27.6 bar) or 133 percent of fire pump controller rated operating pressure, whichever is higher, without losing its accuracy.

12.4.4.4 The pressure recording device shall be spring wound mechanically or driven by reliable electrical means.

12.4.4.5 The pressure recording device shall not be solely dependent upon alternating current (ac) electric power as its primary power source.

12.4.4.6 Upon loss of ac electric power, the electric-driven recorder shall be capable of at least 24 hours of operation.

12.4.4.7 In a nonpressure-actuated controller, the pressure recorder shall not be required.

12.4.5 **Voltmeter.** A voltmeter with an accuracy of ± 5 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 **Battery Recharging.** 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.

12.5.1 **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 rectifier 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(f).
- (8) Means shall be provided on the exterior of the controller to read the voltage and charging current of each battery within an accuracy of ± 2 percent.
- (9) The charger shall be designed such that it will not be damaged or blow fuses during the cranking cycle of the 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 loss of current output on the load side of the direct current (dc) overcurrent protective device where not connected through a control panel. (See 12.4.1.4(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 11.2.7.2.5.2.
- (13) The alternator shall be the primary means of charging when the engine is running.

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 set points as part of the controller shall be provided.

12.7.2.1.1.2* Water piping shall not be extended into the controller.

12.7.2.1.1.3 For multistage multipump 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.

12.7.2.1.1.4 For multistage multipump pumps, a dedicated pressure recorder as described in 12.4.4.1 shall be provided for each discharge port of the pump as part of the controller.

12.7.2.1.1.5 The requirements of 12.7.2.1.1.1 and 12.7.2.1.1.3 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 snubber or restrictive orifice employed within the pressure switch or pressure responsive means.

12.7.2.1.3* Where an electronic pressure sensor is used to automatically control fire pump operation, the fire pump controller shall monitor the transducer during automatic testing.

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 its 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 400 psi (27.6 bar) or 133 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.4.32(a) and Figure A.4.32(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, dry-pipe 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.

12.7.2.2.3 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 suction pressure to another pump shall be arranged to start within 10 seconds before the pump it supplies.

12.7.2.5.2.1 The controllers for pumps arranged in series shall be interlocked to ensure the correct pump starting sequence.

12.7.2.5.3 If water requirements call for more than one pumping unit to operate, the units shall start at intervals of 5 to 10 seconds.

12.7.2.5.4 Failure of a leading driver to start shall not prevent subsequent drivers from starting.

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, disconnecting, 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-flow 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 12.4.4.]

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 shut down a starting cause occurs, the controller shall restart the engine and override the high engine temperature, low oil pressure, or high cooling water temperature shutdowns and run in accordance with 12.7.3.2.

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 operating 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.

12.7.3.3 Starting Equipment Arrangement. The requirements for starting equipment arrangement shall be as follows:

- (1) Two storage battery units, each complying with the requirements of 11.2.7.2.1, shall be provided and so arranged that manual and automatic starting of the engine can be accomplished with either battery unit.
- (2) The starting current shall be furnished by first one battery and then the other on successive operations of the starter.
- (3) The battery chargerover 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.

12.7.5.2.1 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 overspeed shutdown device operates:
 - (a) The controller shall remove power from the engine running devices, prevent further cranking, energize the overspeed fire pump alarm, and lock out until manually reset.
 - (b) Resetting of the overspeed 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 overspeed shutdown device is manually reset.
- (3) 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 alarms.

(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 multisize 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 valved but shall discharge to a safe location.

13.2.1.4 The nozzle chamber, governorvalve 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 pressures 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

13.2.2.3 While the turbine is running at rated pump load, the speed governor shall be capable of adjustment to secure speeds of approximately 5 percent above and 5 percent below the rated speed of the pump.

13.2.2.4 There shall also be provided an independent emergency governing device.

13.2.2.5 The independent emergency governing device shall be arranged to shut off the steam supply at a turbine speed approximately 20 percent higher than the rated pump speed.

13.2.3 Gauge and Gauge Connections.

13.2.3.1 A listed steam pressure gauge shall be provided on the entrance side of the speed governor.

13.2.3.2 A 0.25 in. (6 mm) pipe tap for a gauge connection shall be provided on the nozzle chamber of the turbine.

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) |
|-------------------------|-----------------|------------------------|-------------------|
| 1 | 37 | 25 | 140 |
| 1½ | 85 | 38 | 330 |
| 2 | 150 | 50 | 570 |
| 2½ | 229 | 65 | 870 |
| 3 | 330 | 75 | 1,250 |
| 3½ | 450 | 85 | 1,710 |
| 4 | 590 | 100 | 2,240 |
| 5 | 920 | 125 | 3,490 |
| 6 | 1,360 | 150 | 5,150 |
| 8 | 2,350 | 200 | 8,900 |
| 10 | 3,670 | 250 | 13,900 |
| 12 | 5,290 | 300 | 20,100 |
| 14 | 7,200 | 350 | 27,300 |
| 16 | 9,400 | 400 | 35,600 |

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 4.4.)

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) interwiring, 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.

13.2.3.3 The gauge shall indicate pressures not less than one and one-half times the boiler pressure and in no case less than 240 psi (16.5 bar).

13.2.3.4 The gauge shall be marked "Steam."

13.2.4 Rotor.

13.2.4.1 The rotor of the turbine shall be of suitable material.

13.2.4.2 The first unit of a rotor design shall be type tested in the manufacturer's shop at 40 percent above rated speed.

13.2.4.3 All subsequent units of the same design shall be tested at 25 percent above rated speed.

13.2.5 Shaft.

13.2.5.1 The shaft of the turbine shall be of high-grade steel, such as open-bleach carbon steel or nickel steel.

13.2.5.2 Where the pump and turbine are assembled as independent units, a flexible coupling shall be provided between the two units.

13.2.5.3 Where an overhung rotor is used, the shaft for the combined unit shall be in one piece with only two bearings.

13.2.5.4 The critical speed of the shaft shall be well above the highest speed of the turbine so that the turbine will operate at all speeds up to 120 percent of rated speed without objectionable vibration.

13.2.6 Bearings.

13.2.6.1 Sleeve Bearings. Turbines having sleeve bearings shall have split-type bearing shells and caps.

13.2.6.2 Ball Bearings.

13.2.6.2.1 Turbines having ball bearings shall be acceptable after they have established a satisfactory record in the commercial field.

13.2.6.2.2 Means shall be provided to give visible indication of the oil level.

13.3* Installations. Details of steam supply exhaust, and boiler feed shall be carefully planned to provide reliability and effective operation of a steam turbine-driven fire pump.

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

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 non-variable speed operation shall be available for comparison of the results of the field acceptance test.

14.2.4.1.2 For multistage multipoint 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.

14.2.4.1.3 For self-regulating variable speed fire pump units, a copy of the manufacturer's test curves for self-regulating variable speed constant boost mode, self-regulating variable speed constant discharge mode, and bypass constant speed mode shall be available.

14.2.4.2 At all flow conditions, including those required to be tested in 14.2.6.3, 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.

14.2.4.2.3* For self-regulating variable speed fire pump units, the unit as installed shall equal the performance as indicated on the fire pump unit manufacturer's certified self-regulating variable speed mode shop test data within the accuracy limits of the test equipment.

14.2.5 System Demand. The actual unadjusted fire pump discharge flows and pressures installed 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 ± 2 percent shall be permitted to be used in lieu of calibrated volt/amp meters 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 Automated Inspection and Testing Devices and Equipment.

14.2.6.2.1 Automated inspection and testing devices and equipment installed on the fire pump system shall be tested to ensure the accuracy of the automated inspection and testing devices and equipment.

14.2.6.2.1.1 Automated inspection devices and equipment shall be proven to be as effective as a visual examination.

14.2.6.2.1.2 Automated testing devices and equipment shall produce the same action required by this standard to test a device.

14.2.6.2.2 The testing shall discharge water where required by this standard and NFPA 25.

14.2.6.2.3 Failure of a component or system to pass an automated inspection or test shall result in an audible trouble signal in accordance with NFPA 72.

14.2.6.3 Fire Pump Flow Testing(s).

14.2.6.3.1 The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component.

14.2.6.3.2* Vibrations of the fire pump assembly shall not be of a magnitude to pose potential damage to any fire pump component.

14.2.6.3.3 The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices.

14.2.6.3.3.1 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.

14.2.6.3.4 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.

14.2.6.3.4.1 This reduced capacity shall constitute an acceptance test, provided that the pump discharge exceeds the fire protection system design and flow rate.

14.2.6.3.5 Where the suction to the fire pump is from a break tank, the tank refill rate shall be tested and recorded.

14.2.6.3.5.1 The refill device shall be operated a minimum of five times.

14.2.6.3.6 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 and the 100 percent and 150 percent flow points, to determine if the pump is operating within its design conditions.

14.2.6.3.6.1 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.

14.2.6.4 Variable Speed Pumps.

14.2.6.4.1* Variable speed pumps shall be tested at no-flow, 25 percent, 50 percent, 75 percent, 100 percent, 125 percent, and 150 percent of rated load in the variable speed mode.

14.2.6.4.1.1 Variable speed pumps shall also be tested at minimum, rated, and peak loads, with the fire pump operating at rated speed.

14.2.6.4.2 The fire protection system shall be isolated and the pressure relief valve closed for the rated speed tests required in 14.2.6.4.1.1.

14.2.6.4.3 The fire protection system shall be open and the relief valve set for the variable speed tests required in 14.2.6.4.1.1.

14.2.6.5 Multistage Multipoint Pumps.

14.2.6.5.1 Each discharge outlet on a multistage multipoint fire pump shall be tested in accordance with this standard.

14.2.6.6* Measurement Procedure.

14.2.6.6.1 The quantity of water discharging from the fire pump assembly shall be determined and stabilized.

14.2.6.6.2 Immediately thereafter, the operating conditions of the fire pump and driver shall be measured.

14.2.6.6.3 Positive Displacement Pumps.

14.2.6.6.3.1 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.

14.2.6.6.3.2 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.

14.2.6.6.3.3 The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer's flow performance data.

14.2.6.6.3.4 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.

14.2.6.6.3.5 Flow rates shall be as specified while operating at the system design pressure. Tests shall be performed in accordance with ANSI/HI 3.6, *Rotary Pump Tests*.

14.2.6.6.3.6 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 system liquid.

14.2.6.6.3.7 For water mist positive displacement pumping units, each pump shall be operated manually a minimum of six times during the acceptance test.

14.2.6.6.3.8 For water mist positive displacement pumping units, each of the required automatic operations shall operate all pumps, except as provided in 14.2.6.6.3.9 and 14.2.6.6.3.10.

14.2.6.6.3.9 Where redundant pumps are provided, each of the automatic operations shall operate the number of pumps required to meet system demand.

14.2.6.6.3.10 Where redundant pumps are provided, each pump shall operate for a minimum of three automatic operations.

14.2.6.6.4 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.

14.2.6.6.5* 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.

14.2.6.6.6 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.)

14.2.6.6.7 Engine-Driven Units.

14.2.6.6.7.1 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.

14.2.6.6.7.2 Engine-driven units shall not show signs of overload or stress.

14.2.6.6.7.3 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 11.2.1.1.)

14.2.6.6.7.4 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.

14.2.6.6.8 Steam Turbine-Driven Units. The steam turbine shall maintain its speed within the limits specified in 13.2.2.

14.2.6.6.9 Right Angle Gear Drive Units. The gear drive assembly shall operate without excessive objectionable noise, vibration, or heading.

14.2.6.7 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.

14.2.6.8* 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).

14.2.7.7 Controller Acceptance Test for Electric and Diesel Driven Units.

14.2.7.7.1* 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 driver shall not be required to run for 5 minutes at full speed between successive starts until the 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 service 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 retransfer 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* Test Duration. The fire pump or foam concentrate pump shall be in operation for not less than 1 hour total time during all of the foregoing tests.

14.2.12* Electronic Fuel Management (ECM). For engines with electronic fuel management (ECM) control systems, a function test of both the primary and the alternate ECM shall be conducted.

14.3* 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* 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)* 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 14.5.2.5, 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 reassembly.

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 name-

plate, 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.

14.5.2.2 The replacement of components in fire pumps, fire pump controllers, and drivers shall be performed by factory-authorized representatives or qualified persons acceptable to the authority having jurisdiction.

14.5.2.3* When an ECM on an electronic fuel management-controlled engine is replaced, the replacement ECM shall include the same software programming that was in the original ECM.

14.5.2.4 Component Replacement. The requirements of Table 8.6.1 of NFPA 25 shall be followed for component replacement testing.

14.5.2.4.1 Replacement parts shall be provided that will maintain the listing for the fire pump component whenever possible.

14.5.2.4.2 If it is not possible to maintain the listing of a component or if the component was not originally listed for fire protection use, the replacement parts shall meet or exceed the quality of the parts being replaced.

14.5.2.5 Critical path components include the following features of the pump equipment:

- (1) Fire pumps
 - (a) Impeller, casing
 - (b) Gear drives
- (2) Fire pump controllers (electric or diesel): total replacement
- (3) Electric motor, steam turbines, or diesel engine drivers
 - (a) Electric motor replacement
 - (b) Steam turbine replacement or rebuild
 - (c) Steam regulator or source upgrade
 - (d) Engine replacement or engine rebuild

14.5.2.6 Whenever replacement, change, or modification to a critical path component is performed on a fire pump, driver, or controller, as described in 14.5.2.5, a new acceptance test shall be conducted by the pump manufacturer, factory-authorized representative, or qualified persons acceptable to the authority having jurisdiction.

14.5.2.7 Field Retests.

14.5.2.7.1 The field retest results shall be compared to the original pump performance as indicated by the original factory-certified test curve, whenever it is available.

14.5.2.7.2 The field retest results shall meet or exceed the performance characteristics as indicated on the pump nameplate, and they shall be within the accuracy limits of field testing as stated elsewhere in this standard.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable test paragraphs.

A.1.1 For more information, see NFPA 25 and NFPA 70, Article 695.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or department official may be the authority having jurisdiction.

A.3.2.3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.1.1 Diesel Engine. The oil-diesel engine operates on fuel oil injected near top dead center of the compression stroke. The combustion is effected within the working cylinder and not in external chambers.

A.3.3.2.9 Head. The unit for measuring head is the foot (meter). The relation between pressure expressed in pounds per square inch (bar) and pressure expressed in feet (meters) of head is expressed by the following formulas:

[A.3.3.2.9]

$$\text{Head in feet} = \frac{\text{Pressure in psi}}{0.433 \text{ specific gravity}}$$

$$\text{Head in meters} = \frac{\text{Pressure in bar}}{0.008 \text{ specific gravity}}$$

In terms of foot-pounds (meter-kilograms) of energy per pound (kilogram) of water, all head quantities have the dimension

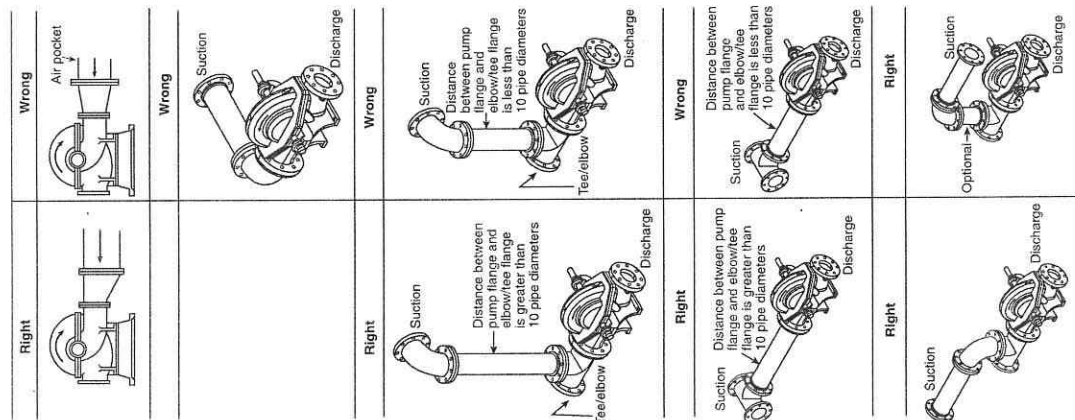


FIGURE A-4.16.6 Right and Wrong Pump Suctions.

Shaded text = Revisions. Δ = Text deletions and figure/table revisions. \bullet = New material.

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A-4.16.10 For more information, see ANSI/HI 9.6.6, *Rotodynamic Pumps for Pump Piping*. (See Figure A-4.16.10.)

A-4.17.4 Flanges welded to the pipe are preferred.

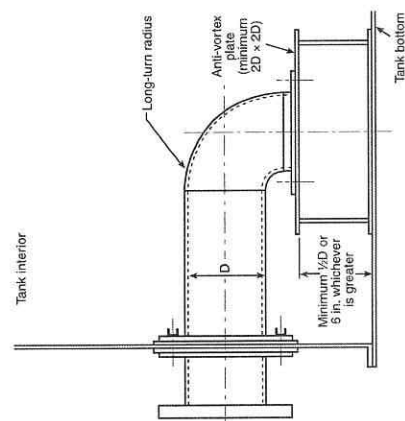
A-4.17.6 The discharge pipe size should be such that, with the pump(s) operating at 150 percent of rated capacity, the velocity in the discharge pipe does not exceed 20 ft/sec (6.1 m/sec).

A-4.17.7 Large fire protection systems sometimes experience severe water hammer caused by backflow when the automatic control shuts down the fire pump. Where conditions can be expected to cause objectionable water hammer, a listed anti-water-hammer check valve should be installed in the discharge line of the fire pump. Automatically controlled pumps in tall buildings could give trouble from water hammer as the pump is shutting down.

Where a backflow preventer is substituted for the discharge check valve, an additional backflow preventer might be necessary in the bypass piping to prevent backflow through the bypass.

Where a backflow preventer is substituted for the discharge check valve, the connection for the sensing line is permitted to be between the last check valve and the last control valve if the pressure sensing line connection can be made without altering the backflow valve or violating its listing. This method can sometimes be done by adding a connection through the test port on the backflow valve. In this situation, the discharge control valve is not necessary, because the last control valve on the backflow preventer serves this function.

Where a backflow preventer is substituted for the discharge check valve and the connection of the sensing line cannot be made within the backflow preventer, the sensing line should be connected between the backflow preventer and the pump's discharge control valve. In this situation, the backflow preventer cannot substitute for the discharge control valve because the sensing line must be able to be isolated.



For SI units, 1 in. = 25.4 mm.

FIGURE A-4.16.10 Anti-Vortex Plate Assembly.

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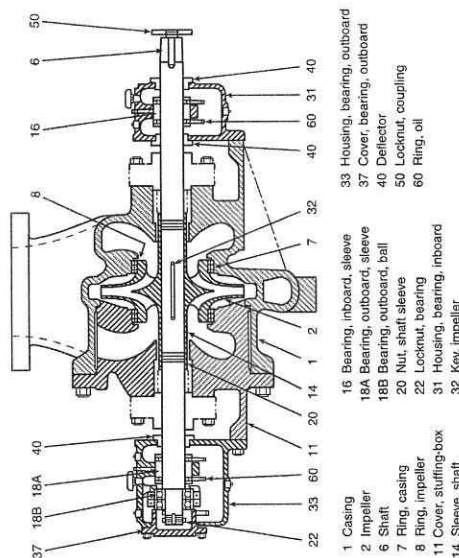


FIGURE A-6.1.1(g) Impeller Between Bearings — Separately Coupled — Single Stage — Radial (Vertical) Split Case.

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 dowelled 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, seasoning, 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-6.5.1.2 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 Satisfactory 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.

A-7.1.1 The vertical shaft turbine-type pump is particularly suitable for fire pump service where the water source is located below ground and where it would be difficult to install any other type of pump below the minimum water level. It was originally designed for installation in drilled wells but is permitted to be used to lift water from lakes, streams, open swamps, and other subsurface sources. Both oil-lubricated enclosed-shaft and water-lubricated open-shaft pumps are used. (See Figure A-7.1.1.) Some health departments object to the use of oil-lubricated pumps; such authorities should be consulted before proceeding with oil-lubricated design.

A-7.2.1.1 Stored water supplies from reservoirs or tanks supplying wet pits are preferable. Lakes, streams, and groundwater supplies are acceptable where investigation shows that they can be expected to provide a suitable and reliable supply.

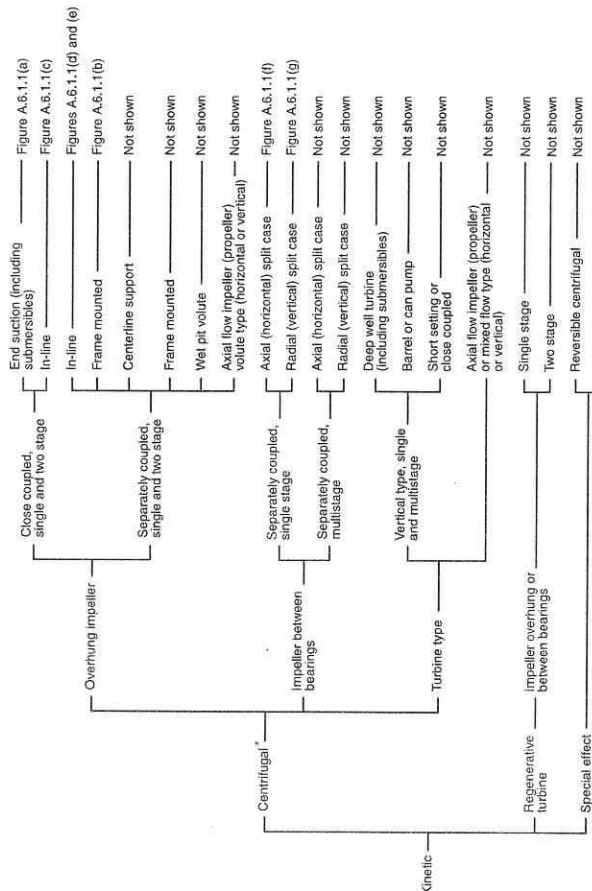
A-7.2.1.2 The authority having jurisdiction can require an aquifer performance analysis. The history of the water table should be carefully investigated. The number of wells already in use in the area and the probable number that can be in use should be considered in relation to the total amount of water available for fire protection purposes.

A-7.2.2.1 See Figure A-7.2.2.1.

A-7.2.2.1.3 The acceptability of a well is determined by a 24-hour test that flows the well at 150 percent of the pump flow rating. This test should be reviewed by qualified personnel (usually a well drilling contractor or a person having experience in hydrology and geology). The adequacy and reliability of the water supply are critical to the successful operation of the fire pump and fire protection system.

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Note: Kinetic pumps can be classified by such methods as impeller or casing configuration, and application of the pump, specific speed, or mechanical configuration. The method used in this chart is based primarily on mechanical configuration.

*Includes radial, mixed flow, and axial flow designs.

FIGURE A.6.1.1(b) Types of Stationary Pumps.

A 10 ft (3.05 m) submergence is considered the minimum acceptable level to provide proper pump operation in well applications. The increase of 1 ft (0.30 m) for each 1000 ft (305 m) increase in elevation is due to loss of atmospheric pressure that accompanies elevation. Therefore, the net positive suction head (NPSH) available must be considered in selection of the pump. For example, to obtain the equivalent of 10 ft (3.05 m) of NPSH available at an elevation of 1000 ft (305 m), approximately 11 ft (3.35 m) of water is required.

Several other design parameters need to be considered in the selection of a vertical turbine pump, including the following:

- (1) **Lubrication when the pump is installed in a well.** Bearings are required to have lubrication and are installed along the lineshaft to maintain alignment. Lubrication fluid is usually provided by a fluid reservoir located aboveground, and the fluid is supplied to each bearing by a copper tube or small pipe. This lubrication fluid should use a vegetable-based material that is approved by the

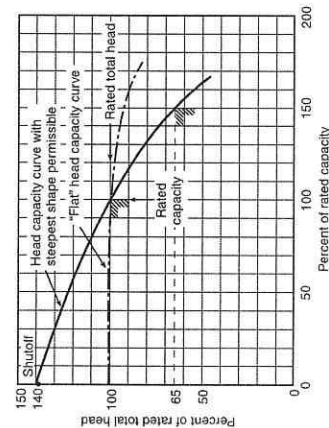
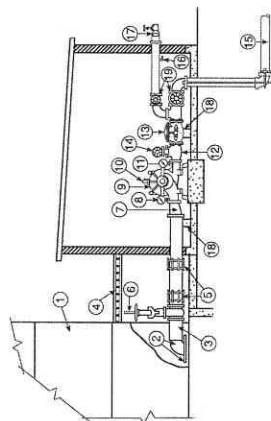


FIGURE A.6.2 Pump Characteristics Curves.



- 1 Aboveground suction tank
- 2 Entrance elbow and square steel vortex plate with dimensions at least twice the diameter of the suction pipe. Distance above the bottom of tank is one-half the diameter of the suction pipe with minimum of 6 in. (152 mm).
- 3 Suction pipe
- 4 Frostproof casing
- 5 Flexible couplings for strain relief
- 6 OS&V gate valve (see 4.16.5 and 4.4.16.5)
- 7 Eccentric reducer
- 8 Suction gauge
- 9 Horizontal split-case fire pump
- 10 Automatic air release
- 11 Discharge gauge
- 12 Reducing discharge tee
- 13 Discharge check valve
- 14 Relief valve (if required)
- 15 Supply pipe for fire protection system
- 16 Drain valve or ball dip
- 17 Hose valve manifold with hose valves
- 18 Pipe supports
- 19 Indicating gate or indicating butterfly valve

FIGURE A.6.3(a) Checking Angular Alignment. (Courtesy of Hydraulic Institute, www.pumps.org.)

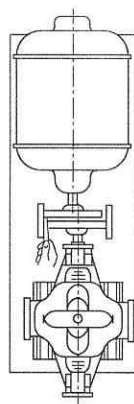


FIGURE A.6.3(b) Checking Parallel Alignment. (Courtesy of Hydraulic Institute, www.pumps.org.)

federal Clean Water Act to minimize water contamination.

- (2) **Determination of the water level in the well.** When a vertical turbine pump is tested, the water level in the well needs to be known so that the suction pressure can be determined. Often the air line for determining the depth is omitted, so testing of the pump for performance is not possible. The arrangement of this device is shown in Figure A.7.3.5.3, and its installation should be included in the system design.

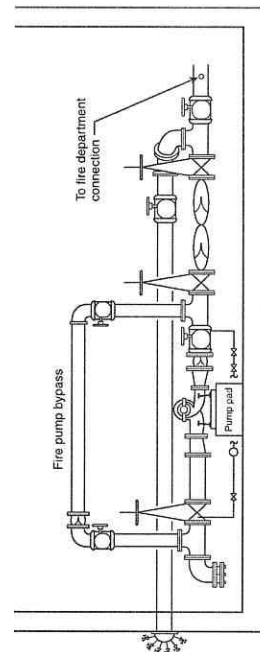
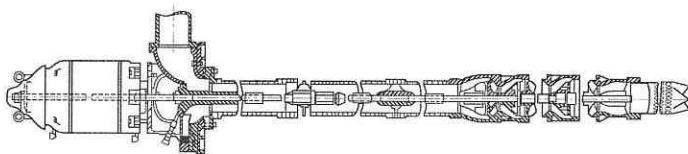


FIGURE A.6.3.1(b) Backflow Preventer Installation.

Water-lubricated, open lineshaft pump, surface discharge, threaded column and bowls



Oil-lubricated, enclosed lineshaft pump, underground discharge, flanged column and bowls

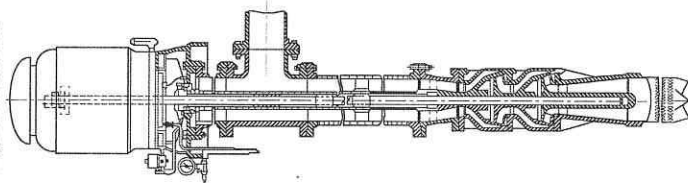
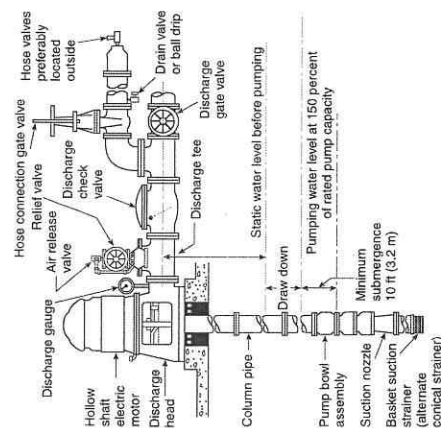


FIGURE A.7.1.1 Water-Lubricated and Oil-Lubricated Shaft Pumps.

A.7.2.2.2 The velocities in the approach channel or intake pipe should not exceed approximately 2 ft/sec (0.7 m/sec), and the velocity in the wet pit should not exceed approximately 1 ft/sec (0.3 m/sec). (See Figure A.7.2.2.2.)

The ideal approach is a straight channel coming directly to the pump. Turns and obstructions are detrimental because they can cause eddy currents and tend to initiate deep-cored vortices. The amount of submergence for successful operation will depend greatly on the approaches of the intake and the size of the pump.

ANSI/HI 9.8 Rotodynamic Pumps for Pump Intake Design recommends sump dimensions for flows 3000 gpm (11,355 L/min) and larger. The design of sumps for pumps with discharge capacities less than 3000 gpm (11,355 L/min) should be guided by the same general principles shown in ANSI/HI 9.8.



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 ft (3.65 m).

FIGURE A.7.2.2.1 Vertical Shaft Turbine-Type Pump Installation in a Well

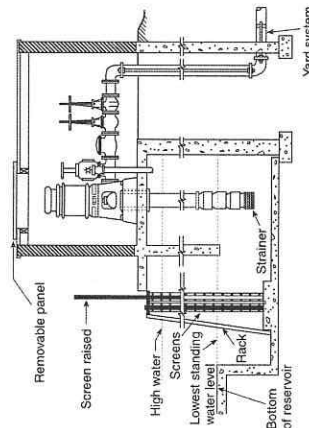


FIGURE A.7.2.2.2 Vertical Shaft Turbine-Type Pump Installation in a Wet Pit.

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 (CO_2) or hydrogen sulfide (H_2S), if the

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Standard for the

Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

2020 Edition

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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.

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 all inspections, testing, and maintenance required by this standard shall conform to this standard.

1.1.1.3 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.

1.1.2 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 the 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 modernized metric system known as 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.

1.4.2 SI units have been converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits. Where nominal or trade sizes exist, the nominal dimension has been recognized in each unit.

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 inspected annually with the pump operating.

8.1.1.2.2 Electrical Connections.

8.1.1.2.2.1* Electrical connections shall be inspected annually and repaired as necessary to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller.

8.1.1.2.2.2* The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.2.1.

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.

8.1.1.2.4.1 Printed circuit boards (PCBs) shall be inspected annually for corrosion to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. (See A.8.1.1.2.2.2.)

8.1.1.2.4.2 The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.4.1. (See A.8.1.1.2.2.1.)

8.1.1.2.5 Cable and Wire Insulation.

8.1.1.2.5.1 Cable and/or wire insulation shall be inspected annually for cracking to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. (See A.8.1.1.2.2.2.)

8.1.1.2.5.2 The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.5.1. (See A.8.1.1.2.2.1.)

8.1.1.2.6 Plumbing.

8.1.1.2.6.1 Plumbing parts, both inside and outside of electrical panels, shall be inspected annually for any leaks to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. (See A.8.1.1.2.2.2.)

8.1.1.2.6.2 The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.6.1. (See A.8.1.1.2.2.1.)

8.1.1.2.7 Fuel tanks, float switches, and supervisory signals for interstitial space shall be tested quarterly for liquid intrusion.

8.1.1.2.8 Supervisory signal circuitry shall be tested annually for high cooling water temperature.

8.1.1.2.9 Fuel tanks shall be tested annually for water and foreign materials.

8.1.1.2.10 Fuel tank vents and overflow piping shall be inspected annually for any obstructions.

8.1.1.2.11 All flexible hoses and connections shall be inspected annually for cracks and leaks.

8.1.1.2.12 Engine crankcase breathers shall be inspected quarterly.

8.1.1.2.13 Exhaust systems, drain condensate traps, and silencers shall be inspected annually.

8.1.1.2.14 Back pressure on the engine turbos shall be measured annually.

8.1.1.2.15 Batteries shall be checked annually as follows:

- (1) Test the specific gravity, state of charge, and charger rates of the batteries
- (2) Clean the terminals of any corrosion
- (3) Ensure that the cranking voltage exceeds 9 V on a 12 V system or 18 V on a 24 V system
- (4) Ensure that only distilled water is used in batteries

8.1.1.2.16 Inspections of Controls and Power Wire Connections.

8.1.1.2.16.1 All controls and power wiring connections shall be inspected annually and repaired as necessary to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. (See A.8.1.1.2.2.2.)

8.1.1.2.16.2 The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.16.1. (See A.8.1.1.2.2.1.)

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 Fuel filter(s) shall be changed as needed, but at a minimum every 50 hours of operation or annually.

8.1.1.2.20 The condition of sacrificial anodes shall be inspected annually and replaced as necessary.

8.1.1.2.21 Circulating water filters shall be replaced annually.

8.1.1.2.22 The accuracy of pressure gauges and sensors shall be inspected annually and replaced or recalibrated when more than 5 percent out of calibration to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. (See A.8.1.1.2.2.2.)

8.1.1.2.22.1 The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.22. (See A.8.1.1.2.2.1.)

8.1.1.2.22.2 If replacement or recalibration is required, proper personal protective equipment in accordance with NFPA 70E or an approved equivalent shall be used.

Table 8.1.1.2 Summary of Fire Pump Inspection, Testing, and Maintenance

| Inspection | Item | Frequency | Reference |
|--|------|--------------------------------|---------------------|
| Alignment | | Annually | 8.3.6.4 |
| Cable/wire insulation | | Annually | 8.1.1.2.5 |
| Diesel engine system | | Weekly | 8.2.2(4) |
| Electric system | | Weekly | 8.2.2(3) |
| Engine crankcase breather | | Quarterly | 8.1.1.2.12 |
| Exhaust system, drain condensate trap, and silencers | | Annually | 8.1.1.2.13 |
| Flexible hoses and connections | | Annually | 8.1.1.2.11 |
| Fuel tank vents and overflow | | Annually | 8.1.1.2.10 |
| Pump | | Annually | 8.1.1.2.6 |
| Printed circuit board (PCB) corrosion | | Annually | 8.1.1.2.4 |
| Pump house/room | | Weekly | 8.2.2(2) |
| Shaft movement or endplay while running | | Weekly | 8.2.2(1) |
| Steam pump system | | Annually | 8.1.1.2.1 |
| Section screens | | Weekly | 8.2.2(5) |
| Section screens | | Annually | 8.3.3.15 |
| Test | | | |
| Automatic transfer switch | | Annually | 8.3.3.12 |
| Automatic transfer switch and emergency/sandby generators | | Per NFPA 110 | 8.3.6.1, 8.3.6.2 |
| Diesel engine-driven fire pump (no flow) | | Weekly | 8.3.1.1 |
| Diesel fuel testing | | Annually | 8.3.4.1 |
| Electric motor-driven fire pump (no flow) | | Weekly/monthly | 8.3.1.2 |
| Electronic control module (ECM) | | Annually | 8.3.3.16 |
| Fire pump alarm signals | | Annually | 8.3.3.13 |
| Flow meters | | Annually | 8.3.3.3 |
| Fuel tank, float switch, and supervisory signal for interstitial space | | Quarterly | 8.1.1.2.7 |
| Gauges, transducers, and other devices used for testing | | Annually | 8.3.3.5.2 |
| Main pressure relief valve | | Annually | 8.3.3.11, 8.3.6.2.3 |
| Pump house/room environmental conditions | | Annually | 8.3.6.3 |
| Pump operation (no flow) | | Weekly/monthly | 8.3.2, 8.3.5 |
| Pump performance (flow) | | Annually | 8.3.3, 8.3.5 |
| 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 | 8.1.1.2.21 |
| Control and power wiring connections | | Annually | 8.1.1.2.16 |
| Controller and all other components of the pump assembly | | Per manufacturer | 8.5 |
| Diesel active fuel maintenance system | | Annually or per manufacturer | 8.3.4.3 |
| Diesel engine system | | Per manufacturer | 8.5 |
| Electric motor and power system | | Per manufacturer | 8.5 |
| Electrical connections | | Annually | 8.1.1.2.9 |
| Engine lubricating oil | | 50 operating hours or annually | 8.1.1.2.17 |
| Engine oil filter | | 50 operating hours or annually | 8.1.1.2.18 |
| Fuel filter | | 50 operating hours or annually | 8.1.1.2.19 |
| Fuel tank — check for water and foreign materials | | Annually | 8.1.1.2.9 |
| Measure back pressure on engine turbo | | Annually | 8.1.1.2.14 |
| Power transmission components with elastomeric materials (including torsional couplings) | | 5 years or per manufacturer | 8.1.1.2.23 |
| Pressure gauges and sensors | | Annually | 8.1.1.2.22 |
| Pump and motor bearings and coupling | | Annually or as required | 8.1.1.2.3 |
| Sacrificial anode | | Annually | 8.1.1.2.20 |

8.1.1.2.23 Power transmitting components used in pump drives that include elastomeric materials, such as torsional couplings, shall be replaced every 5 years or as required by the component manufacturer for a specific elastomeric material.

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 or above the lowest permissible suction pressure 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 still can be met by the pump and 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 Driver. 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.

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 room with electric motor or diesel engine-driven pumps with engine heaters.
- (b) Heat is adequate, not less than 70°F (21°C) for pump room with diesel engine-driven pumps without engine heaters.
- (c) Ventilating louvers are free to operate.
- (d) Excessive water does not collect on the floor.
- (e) Coupling guard is in place.

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 connection valve is closed, and the line to test valves is free of water.

Electrical system conditions are determined as follows:

- (a) Controller pilot light (power on) is illuminated.
- (b) Transfer switch normal pilot light is illuminated.
- (c) Isolating 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.

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 time meter 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.

8.3* Testing

8.3.1 Frequency.

8.3.1.1* 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.

8.3.1.1.1 Except as permitted in 8.3.1.1.2, a weekly test frequency shall be required.

8.3.1.1.2* The test frequency shall be permitted to be established by an approved risk analysis.

8.3.1.2* A no-flow test shall be conducted for electric motor-driven fire pumps on a test frequency in accordance with 8.3.1.2.1, 8.3.1.2.2, 8.3.1.2.3, or 8.3.1.2.4.

8.3.1.2.1 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.

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.

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 8.3.2.1.1.2, the circulation relief valve shall discharge a small flow of water.

8.3.2.1.1.2 The circulation relief valve shall not operate when the flow through the main pressure relief valve is greater than weeping.

8.3.2.1.2 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.

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.

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 unless automated inspection and testing is performed in accordance with 8.3.2.10 including the provision for "automated engine shutdown" indicated in 8.3.2.10.3 for diesel engine drives.

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 gauge 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 where such information is available without having to open an energized electric motor-driven fire pump controller
- (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 controllers).

(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 water flow.

(4) Steam system procedure is as follows:

(a) Record the steam pressure gauge reading.

(b) Observe the time for turbine to reach running speed.

8.3.2.10 Remotely Monitored Automated Testing.

8.3.2.10.1 Remotely monitored automated testing performed in accordance with 4.6.6 shall be permitted for the no-flow test.

8.3.2.10.2 All of the pertinent observations or adjustments specified in the checklists described in 8.3.2.8 and 8.3.2.9 shall be performed.

8.3.2.10.2.1 Any abnormalities shall be recorded.

8.3.2.10.2.2 If, during the automated test, it becomes apparent that the packing gland nuts need to be adjusted as described in 8.3.2.9(1)(d), the need for adjustment shall be recorded and the necessary adjustment shall be made by qualified personnel.

8.3.2.10.3 The controller for a diesel engine-driven fire pump shall be equipped with automatic engine shutdown as referenced in 12.7.2.7 of NFPA 20.

8.3.2.10.4 Qualified personnel shall be able to respond to the pump location upon abnormal condition within 5 minutes.

8.3.3 Annual Flow Testing

8.3.3.1* Except as permitted in 8.3.3.4, an annual test of each constant speed pump assembly shall be conducted by qualified personnel under no-flow (churn), 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.

8.3.3.2* Except as permitted in 8.3.3.4, an annual test of each variable-speed pump assembly shall be conducted by qualified personnel under variable-speed control under no-flow (churn),

25 percent, 50 percent, 75 percent, 100 percent, 125 percent, and 150 percent of the rated pump capacity flow of the fire pump by controlling the quantity of water discharge through approved test devices.

8.3.3.3 Except as permitted in 8.3.3.4, an annual test of each variable speed pump assembly shall be conducted by qualified personnel under constant speed control under no-flow (churn), 100 percent rate, and 150 percent of the pump rated capacity flow of the fire pump by controlling the quantity of water discharged through approved test devices.

8.3.3.4 If available suction supplies do not allow flowing of 150 percent of the rated pump capacity, the fire pump shall be tested at flow rates at 100 percent of the rated pump flow rate, and at the maximum flow allowed at the lowest permissible suction pressure.

8.3.3.5 Test Equipment. Calibrated test equipment shall be provided to determine net pump pressures, rate of flow through the pump, and speed.

8.3.3.5.1 Gauges, transducers, and other devices used for measurement during the test shall bear a label with the latest date of calibration.

8.3.3.5.2 Gauges, transducers, and other devices, with the exception of flow meters, used for measurement during the test shall be calibrated a minimum of annually to an accuracy level of ± 1 percent.

8.3.3.5.3* Flow meters shall be calibrated annually to an accuracy level of ± 3 percent.

8.3.3.6 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.

8.3.3.7 The sensing/measuring elements in a flow meter shall be calibrated in accordance with 8.3.3.5.

8.3.3.8 Discharge orifices shall be listed or constructed to a recognized standard with a known discharge coefficient.

8.3.3.9 The annual test shall be conducted as follows:

- (1) The arrangement described in 8.3.3.9.1 or 8.3.3.9.2 shall be used at a minimum of every third year.
- (2)* The arrangement described in 8.3.3.9.3 shall be permitted to be used 2 out of every 3 years.

8.3.3.9.1 Use of Pump Discharge via Hose Streams.

8.3.3.9.1.1 Pump suction and discharge pressures and the flow measurements of each hose stream shall determine the total pump output.

8.3.3.9.1.2* Prior to flow testing, the entity performing testing shall make the owner or their representative aware of the location, approximate flow rate, and duration of flow testing.

8.3.3.9.2 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.

8.3.3.9.3 Use of Pump Discharge via Bypass Flowmeter to Pump Suction (Closed-Loop Metering).

8.3.3.9.3.1 Pump suction and discharge pressures and the flowmeter measurements shall determine the total pump output.

8.3.3.9.3.2 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 manufacturers.

8.3.3.9.3.3 If the test results are not consistent with the previous annual test, the test shall be repeated using the test arrangement described in 8.3.3.9.1.

8.3.3.9.3.4 If testing in accordance with 8.3.3.9.1 is not possible, a flowmeter calibration shall be performed and the test shall be repeated.

8.3.3.10 The pertinent visual observations, measurements, and adjustments specified in the following checklists shall be conducted annually while the pump is running and flowing water under the specified output condition:

- (1) At no-flow condition (churn), 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) Where an external means is provided on the controller, record the electric motor voltage and current (all lines).
 - (b) Record the pump speed in rpm.
 - (c) Record the simultaneous (approximate) 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.

8.3.3.11* 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.

8.3.3.11.1* The pressure relief valve shall also be observed during each flow condition to determine whether the pressure relief valve closes at the proper pressure.

8.3.3.11.2 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.

8.3.3.11.2.1 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.

8.3.3.11.3 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 manufacturers.

8.3.3.12 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 following to include in the pump test results:

- (a) The voltage where an external means is provided on the controller.
- (b) The amperage where an external means is provided on the controller.
- (c) The rpm.
- (d) Suction pressure.
- (e) Discharge pressure.
- (4) Verify that the pump continues to perform at peak horsepower 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.

8.3.3.13* Alarm conditions shall be simulated by activating alarm circuits at alarm sensor locations and confirmed for proper operation.

8.3.3.13.1* Alarm sensors located within electric motor-driven fire pump controllers that cannot be accessed without opening an energized electric motor-driven fire pump controller shall be tested at an alternative location outside of the controller.

8.3.3.14 Safety. *[See also A.7.9.6.]*

8.3.3.14.1 Section 4.9 shall be followed for safety requirements while working near electric motor-driven fire pumps.

8.3.3.15* Suction Screens. After the waterflow portions of the annual test or fire protection system activations, the suction screens shall be inspected and cleared of any debris or obstructions.

8.3.3.16* 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 Stock (B100) for Middle Distillate Fuels*, as approved by the engine manufacturer, using ASTM D7462, *Standard Test Method for Oxidation Stability of Biodiesel (B100) and Blends of Biodiesel with Middle Distillate Petroleum Fuel (Accelerated 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. [20:14.2.6.4.3]

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. [20:14.2.6.4.3.1]

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. [20:14.2.6.4.3.2]

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. [20:14.2.6.4.3.3]

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. [20:14.2.6.4.3.4]

8.3.5.6 Flow rates shall be as specified while operating at the system design pressure. Tests shall be performed in accordance with HI 3.6, *Rotary Pump Tests*. [20:14.2.6.4.3.5]

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. [20:14.2.6.4.3.6]

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, illumination) 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 net 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 8.3.7.2.9.

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 all of the following conditions are satisfied:

- (1) Fire pump meets the flow and pressure requirements of the most demanding system(s) being supplied by the fire pump based on owner-provided system design information.
- (2)* Fire pump supplies 100 percent of rated flow.
- (3)* The net pressure at each flow point is at least 95 percent of one of the following:
 - (a) Original manufacturer's pump curve.
 - (b) Original unadjusted field test curve.
 - (c) Test curve generated from the fire pump nameplate.

8.3.7.2.4* The following actions shall be required upon failure to meet the criteria in 8.3.7.2.3:

- (1) The owner shall be notified in writing of the unacceptable test results.
- (2) An investigation shall be conducted into the cause of the unacceptable test results.
- (3) Failure to provide the maximum system demand shall be deemed an impairment.
- (4) Excessive vibration and/or excessively worn or loose components shall be deemed a deficiency.
- (5) Degraded performance that still provides the maximum system demand shall be deemed a functional deficiency.
- (6) The owner shall be notified in writing of corrections completed.

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.

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 At 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 alternative 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 | | | | | |
| Entire pump assembly | | X | | X | Perform acceptance test in accordance with NFPA 20 |
| Impeller/rotating assembly | | X | | X | Perform acceptance test in accordance with NFPA 20 |
| Casing | | | | X | NFPA 20 with alignment inspection |
| Bearings | | | | X | Perform annual test in accordance with 8.3.3 |
| 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 | 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 | X | Perform acceptance test in accordance with NFPA 20 |
| Electronic component or module that can prevent the controller from starting or running | | | | 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 8.3.2 |
| Plumbing part | | | | X | Perform weekly test in accordance with 8.3.2 |
| Isolating switch | | | | 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 |
| Circuit breaker | | | | X | Test in accordance with 8.3.3, including six starts at peak load and operate pump for a minimum of 1 hour |
| Electrical connections | X | | | | Perform test in accordance with 8.3.2 |
| Main contactor | | X | | X | Perform test in accordance with 8.3.3 with six starts |
| Power monitor | | | | X | Perform six operations of the circuit breaker/ isolation switch disconnect (cycle the power on/off) |
| Start relay | | | | X | Perform test in accordance with 8.3.2 with six starts |
| Pressure switch | X | | | X | Perform test in accordance with 8.3.2 and exercise six times automatically |
| Pressure transducer | X | | | X | Perform six automatic no-load starts |
| Manual start or stop switch | | | X | X | Perform six operations under load |
| Transfer switch — load-carrying parts | | X | X | X | Test in accordance with 8.3.3, including six starts at peak horsepower load, operate pump for a minimum of 1 hour, and transfer from normal power to emergency power and back one time |
| Transfer switch — no-load parts | | | X | X | Perform six no-load operations of transfer of power |
| Electric Motor Driver | | | | | |
| Electric motor | | X | X | X | Perform acceptance test in accordance with NFPA 20 with alignment inspection |
| Motor bearings | | | | X | Perform annual test in accordance with 8.3.3 |
| Incoming power conductors | | | | X | Test in accordance with 8.3.3 and operate pump for a minimum of 1 hour, including six starts at peak load |
| Diesel Engine Driver | | | | | |
| Entire engine | | | X | X | Perform acceptance test in accordance with NFPA 20 with alignment inspection |
| Fuel transfer pump | X | | X | X | 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 from replaced battery in accordance with 8.3.2 |
| 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 | 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 | 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(2) |
| Suction/discharge fittings | | X | | X | Perform visual inspection in accordance with 8.2.2(2) |
| Suction/discharge valves | | X | X | X | Perform operational test in accordance with 13.3.3.1 |

Chapter 9 Water Storage Tanks**9.2 Inspection.****9.1* General.****9.1.1 Minimum Requirements.**

9.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of water storage tanks dedicated to fire protection use.

9.1.1.2 Table 9.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

9.1.2 **Common Components and Valves.** Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

9.1.3 **Obstruction Investigations.** The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

9.1.4 **Impairments.** The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

9.2.1 Water Level.

9.2.1.1* The water level in tanks equipped with supervised water level alarms that are supervised in accordance with NFPA 72 shall be inspected quarterly.

9.2.1.2 The water level in tanks not equipped with supervised water level alarms connected to a constantly attended location shall be inspected monthly.

9.2.1.3 Water Level Verification.

9.2.1.3.1 Inspection of water level shall be verified through the level indicator where provided.

9.2.1.3.2* The tank shall be at full or at the designed water level.

9.2.2 Heating System.

9.2.2.1 Tank heating systems installed on tanks equipped with low water temperature alarms supervised in accordance with NFPA 72, connected to a constantly attended location shall be inspected quarterly during the heating season.

รายงานการตรวจเช็ค

ประจำเดือน มิถุนายน 2567

การตรวจเช็ค

ระบบแจ้งเหตุเพลิงไหม้และตู้ควบคุม

เครื่องสูบลูกสูบ ปั๊มไฟฟ้าทางออกฉุกเฉิน

ระบบดับเพลิง อังคัมพลิง



Location

บริษัท ไดคิ ออูมิเนียม อินดัสทรี (ประเทศไทย) จำกัด

(โรงงานระยอง)

คำนำ

รายงานฉบับนี้ จัดทำขึ้นเพื่อเสนอข้อมูลการตรวจเช็คถังดับเพลิงในวันที่ 14 มิถุนายน 2567 ของบริษัท ไลอ้อนนิคม อินดัสทรี (ประเทศไทย) (โรงงานระยอง) เพื่อให้ทราบถึง ผลการตรวจเช็ค อุปกรณ์ถังดับเพลิงใหม่ ถังลงไฟฟ้าออกฉุกเฉิน ถังลงไฟฉุกเฉินฯ ทั้งนี้เพื่อให้พร้อมต่อการใช้งานในสถานการณ์ฉุกเฉิน



บริษัท นิสิน เซฟตี้ แอนด์ เซอร์วิส จำกัด

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| lay out | |



บริษัท มิรา เซฟตี้ เซอร์วิส แอนด์ ซัพพลาย จำกัด (สำนักงานใหญ่)
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การตรวจสอบตู้ควบคุม Fire Alarm Control Panel (No.1)

| ลำดับ | รายการตรวจสอบ | ผ่าน | ไม่ผ่าน | หมายเหตุ |
|-------|---|------|---------|----------|
| | การตรวจสอบสภาพ (Checking) ของตู้ควบคุมระบบสัญญาณแจ้งเหตุเพลิงไหม้ | | | |
| 1 | ตรวจสอบสภาพโดยรวมภายนอกและภายในตู้ (Housing) | ✓ | | |
| 2 | ตรวจสอบสายที่เชื่อมต่อ (Wiring) อยู่ภายในตู้ | ✓ | | |
| 3 | ตรวจสอบสภาพบอร์ดควบคุม (Control Board) และการ์ดตัวเชื่อมต่อ (Interface Card) | ✓ | | |
| 4 | ตรวจสอบสายต่อ (Terminal Strip) บนบอร์ดควบคุม (Control Board) และการ์ด (Card) | ✓ | | |
| 5 | ตรวจสอบสายต่อปลั๊กไฟ (Transformer Power Supply) | ✓ | | |
| 6 | ตรวจสอบแรงดันไฟบน (Transformer) และแรงดันไฟลงแบตเตอรี่ | ✓ | | 27.35 V |
| 7 | ตรวจสอบสภาพโดยรวมของแบตเตอรี่ (Battery) และตารางชาร์จแบตเตอรี่ | ✓ | | |
| 8 | ตรวจสอบสภาพหน้าจอแสดงผล (LCD Display) กับไมโครควบคุม และสวิตช์ปุ่มกด (Keypad) | ✓ | | |
| 9 | ตรวจสอบหลอดไฟแจ้งเตือน (LED Status) การแจ้งเตือนต่างๆ | ✓ | | |
| 10 | ตรวจสอบฟังก์ชัน (Function) การควบคุม (Control) และ การส่งงาน (Relay) ต่างๆ | ✓ | | |
| | การทำความสะอาด (Cleaning) ตู้ควบคุมระบบสัญญาณแจ้งเหตุเพลิงไหม้ | | | |
| 11 | ทำความสะอาดทั้งภายในและภายนอกตู้ | ✓ | | |
| 12 | ทำความสะอาดหน้าจอแสดงผล (LCD Display) กับไมโครควบคุม (Keypad) | ✓ | | |
| 13 | ทำความสะอาดบอร์ดควบคุม (Control Board) และการ์ด (Card) ต่างๆ | ✓ | | |
| 14 | ตรวจสอบและขันน็อต Terminal Strip สายเชื่อมต่อไฟไม่แน่น | ✓ | | |
| 15 | จัดเรียงสายไฟภายในตู้ให้เรียบร้อย | ✓ | | |
| | ทดสอบการทำงานของ (Testing) ของตู้ควบคุมระบบสัญญาณแจ้งเหตุเพลิงไหม้ | | | |
| 16 | ทดสอบการแจ้งเตือนหน้าแสดงผล (LCD Display) กับไมโครควบคุม (Keypad) | ✓ | | |
| 17 | ทดสอบการแจ้งเตือนหลอดไฟแจ้งเตือน (LED Status) การแจ้งเตือนต่างๆ | ✓ | | |
| 18 | ทดสอบระบบการตรวจสอบแบตเตอรี่ (Supervisory) | ✓ | | |
| 19 | ทดสอบการแจ้งเตือนหลอดไฟแจ้งเตือน (History Event) | ✓ | | |
| 20 | ทดสอบการรีเซ็ตตู้ควบคุมด้วยการกดปุ่มรีเซ็ต (History Event) | ✓ | | |
| 21 | ทดสอบการจ่ายไฟของแบตเตอรี่ และการชาร์จไฟ (Recharge Battery) จัดไฟใหม่ | ✓ | | |
| 22 | ทดสอบระบบการแจ้งเตือนสัญญาณการปล่อยสัญญาณ (Signal Initiating Devices) | ✓ | | |
| 23 | ทดสอบระบบการส่งสัญญาณ ไปยังงานอุปกรณ์แจ้งเตือนสัญญาณ (Audible Alarm Devices) | ✓ | | |
| 24 | ทดสอบแบตเตอรี่ตู้ควบคุมสัญญาณแจ้งเตือนสัญญาณ (Acknowledge) ที่ตู้ควบคุม | ✓ | | |
| 25 | ทดสอบแบตเตอรี่ตู้ควบคุมสัญญาณแจ้งเตือนสัญญาณ (Reset) ที่ตู้ควบคุม | ✓ | | |



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รายงานสรุปผลการทดสอบ
ระบบสัญญาณแจ้งเหตุเพลิงไหม้ระบบดับเพลิง
เครื่องแจ้งเหตุเพลิงไหม้

บริษัท ไลต์ โซลูชั่น อิมเมจ (ประเทศไทย) จำกัด (โรงงานรวมผล)
วันที่ทดสอบ : 14 มิถุนายน 2567

ระบบสัญญาณแจ้งเหตุเพลิงไหม้
1. ตู้ควบคุมสัญญาณแจ้งเหตุเพลิงไหม้ (FCP-1) (FCP-2) (FCP-3) ปกติ

2. Heat Detector ปกติ

3. Smoke Detector ปกติ

4. Fixed Temp. Heat Detector ปกติ

5. Beam Smoke Detector ปกติ

6. Linear Heat Detector ไม่สามารถทดสอบสัญญาณไฟ เนื่องจากหลอดไฟชำรุดให้ใช้หลอดเก่า

7. Manual Station ปกติ

8. Free Alarm Bell ปกติ

9. Light ปกติ

เครื่องแจ้งเหตุเพลิงไหม้ ยี่ห้อไฟทองแดง

1. เครื่องไฟทองแดง ปกติ ยี่ห้อไฟ - เครื่องแจ้งเหตุเพลิงไหม้ 1 ชุด

2. ปุ่มกดไฟทองแดง ปกติ

เครื่องแจ้งเหตุเพลิงไหม้

1. เครื่องแจ้งเหตุเพลิงไหม้ หุ่นยนต์แจ้ง ปกติ

ยี่ห้อไฟ - เครื่องแจ้งเหตุเพลิงไหม้ 1 ชุด

2. เครื่องแจ้งเหตุเพลิงไหม้ หุ่นยนต์แจ้ง หุ่นยนต์แจ้ง ปกติ

3. เครื่องแจ้งเหตุเพลิงไหม้ Class D ปกติ

ระบบแจ้งเหตุเพลิงไหม้

1. อุปกรณ์สัญญาณแจ้งเหตุเพลิงไหม้ ปกติ

2. อุปกรณ์สัญญาณแจ้งเหตุเพลิงไหม้ ปกติ

(นายวิน ขวัญใจ)
ผู้ดำเนินการตรวจเช็ค



บริษัท มิรา เซอร์วิส แอนด์ ซัพพลาย จำกัด (มหาชน)
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การตรวจเช็คอุปกรณ์

สถานที่ตรวจเช็ค
อาคาร หอประชุม อาคาร (ประเภทห้องสมุด) (ประเภทโรงเรียน)
วันที่ ตรวจเช็ค 14 มิถุนายน 2567

| โซน / ลำดับที่ | ประเภทอุปกรณ์ | ผลการตรวจ | | หมายเหตุ |
|----------------|----------------|-----------|---------|----------|
| | | ปกติ | ผิดปกติ | |
| 1/1 | Heat Detector | ✓ | | |
| 1/2 | Heat Detector | ✓ | | |
| 1/3 | Heat Detector | ✓ | | |
| 1/4 | Heat Detector | ✓ | | |
| 1/5 | Heat Detector | ✓ | | |
| 1/6 | Heat Detector | ✓ | | |
| 1/7 | Heat Detector | ✓ | | |
| 1/8 | Heat Detector | ✓ | | |
| 1/9 | Smoke Detector | ✓ | | |
| 1/10 | Smoke Detector | ✓ | | |
| 1/11 | Smoke Detector | ✓ | | |
| 1/12 | Smoke Detector | ✓ | | |
| 1/13 | Manual Station | ✓ | | |
| 1/13 | Alarm Bell | ✓ | | |
| 1/13 | Light | ✓ | | |
| 2/1 | Heat Detector | ✓ | | |
| 2/2 | Heat Detector | ✓ | | |
| 2/3 | Heat Detector | ✓ | | |
| 2/4 | Heat Detector | ✓ | | |
| 2/5 | Heat Detector | ✓ | | |
| 2/6 | Heat Detector | ✓ | | |
| 2/7 | Heat Detector | ✓ | | |
| 2/8 | Smoke Detector | ✓ | | |
| 2/9 | Smoke Detector | ✓ | | |
| 2/10 | Smoke Detector | ✓ | | |
| 2/11 | Manual Station | ✓ | | |
| 2/11 | Alarm Bell | ✓ | | |
| 2/11 | Light | ✓ | | |



บริษัท มิรา เซอร์วิส แอนด์ ซัพพลาย จำกัด (มหาชน)
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TAX ID : 02056200333

| | | | | |
|-----|---------------------|---|--|--|
| 3/1 | Manual Station | ✓ | | |
| 3/1 | Alarm Bell | ✓ | | |
| 3/1 | Light | ✓ | | |
| 3/2 | Manual Station | ✓ | | |
| 3/2 | Alarm Bell | ✓ | | |
| 3/2 | Light | ✓ | | |
| 3/3 | Beam Smoke Detector | ✓ | | |
| 4/1 | Beam Smoke Detector | ✓ | | |
| 4/2 | Beam Smoke Detector | ✓ | | |
| 4/3 | Manual Station | ✓ | | |
| 4/3 | Alarm Bell | ✓ | | |
| 4/3 | Light | ✓ | | |
| 4/4 | Manual Station | ✓ | | |
| 4/4 | Alarm Bell | ✓ | | |
| 4/4 | Light | ✓ | | |
| 4/5 | Manual Station | ✓ | | |
| 4/5 | Alarm Bell | ✓ | | |
| 4/5 | Light | ✓ | | |
| 4/6 | Manual Station | ✓ | | |
| 4/6 | Alarm Bell | ✓ | | |
| 4/6 | Light | ✓ | | |
| 5/1 | Beam Smoke Detector | ✓ | | |
| 5/2 | Beam Smoke Detector | ✓ | | |
| 5/3 | Manual Station | ✓ | | |
| 5/3 | Alarm Bell | ✓ | | |
| 5/3 | Light | ✓ | | |
| 5/4 | Manual Station | ✓ | | |
| 5/4 | Alarm Bell | ✓ | | |
| 5/4 | Light | ✓ | | |
| 5/5 | Manual Station | ✓ | | |
| 5/5 | Alarm Bell | ✓ | | |
| 5/5 | Light | ✓ | | |
| 5/6 | Manual Station | ✓ | | |
| 5/6 | Alarm Bell | ✓ | | |
| 5/6 | Light | ✓ | | |
| 5/7 | Manual Station | ✓ | | |
| 5/7 | Alarm Bell | ✓ | | |
| 5/7 | Light | ✓ | | |



บริษัท มิรา เซอร์วิส แอนด์ ซัพพลาย จำกัด (สำนักงานใหญ่)
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เลขประจำตัวผู้เสียภาษี : 0205652005393

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TAX ID : 0205652005393

| | | | |
|----|---------------------------|---|--|
| 61 | Smoke Detector | ✓ | |
| 62 | Heat Detector | ✓ | |
| 71 | Smoke Detector | ✓ | |
| 72 | Smoke Detector | ✓ | |
| 73 | Smoke Detector | ✓ | |
| 74 | Smoke Detector | ✓ | |
| 75 | Smoke Detector | ✓ | |
| 76 | Smoke Detector | ✓ | |
| 77 | Fixed Temp. Heat Detector | ✓ | |
| 78 | Manual Station | ✓ | |
| 79 | Alarm Bell | ✓ | |
| 81 | Light | ✓ | |
| 82 | Heat Detector | ✓ | |
| 83 | Manual Station | ✓ | |
| 84 | Alarm Bell | ✓ | |
| 85 | Light | ✓ | |
| 86 | Manual Station | ✓ | |
| 87 | Alarm Bell | ✓ | |
| 88 | Light | ✓ | |



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การตรวจสอบตู้ควบคุม Fire Alarm Control Panel(No.2)

| ลำดับ | รายการตรวจสอบ | ผ่าน | ไม่ผ่าน | หมายเหตุ |
|-------|--|------|---------|----------|
| | การตรวจสอบสภาพ (Checking) ของตู้ควบคุมระบบสัญญาณแจ้งเหตุเพลิงไหม้ | | | |
| 1 | ตรวจสอบสภาพโดยรวมที่ภายนอกและภายในตู้ (Housing) | ✓ | | |
| 2 | ตรวจสอบสายที่เชื่อมต่อ (Wiring) อยู่ภายในตู้ | ✓ | | |
| 3 | ตรวจสอบสภาพบอร์ดควบคุม (Control Board) และการต่อสายเคเบิล (Interface Card) | ✓ | | |
| 4 | ตรวจสอบสายต่อ (Terminal Strip) บอร์ดควบคุม (Control Board) และการ์ด (Card) | ✓ | | |
| 5 | ตรวจสอบหม้อแปลงไฟ (Transformer Power Supply) | ✓ | | |
| 6 | ตรวจสอบแบตเตอรี่ (Battery) และแผงไฟจากแบตเตอรี่ | ✓ | | |
| 7 | ตรวจสอบสภาพโดยรวมของแบตเตอรี่ (Battery) และตัวควบคุม | ✓ | | 27.30 V |
| 8 | ตรวจสอบสภาพหน้าจอแสดงผล (LCD Display) กับแป้นควบคุม และสวิตช์ปุ่มกด (Keypad) | ✓ | | |
| 9 | ตรวจสอบหลอดไฟแสดงสถานะ (LED Status) ตามแจ้งเตือนต่างๆ | ✓ | | |
| 10 | ตรวจสอบฟังก์ชัน (Function) การควบคุม (Control) และ การส่งงาน (Relay) ต่างๆ | ✓ | | |
| | การทดสอบอะลูมิเนียม (Alarm) ซึ่งรับสัญญาณระบบสัญญาณแจ้งเหตุเพลิงไหม้ | | | |
| 11 | ทดสอบสถานะภายนอกและภายในตู้ | ✓ | | |
| 12 | ทดสอบสถานะของหน้าจอแสดงผล (LCD Display) กับแป้นควบคุม (Keypad) | ✓ | | |
| 13 | ทดสอบสถานะของบอร์ดควบคุม (Control Board) และการ์ด (Card) ต่างๆ | ✓ | | |
| 14 | ตรวจสอบและขันน็อต Terminal Strip สำหรับเชื่อมต่อไฟ | ✓ | | |
| 15 | จัดเรียงสายไฟภายในตู้ให้เรียบร้อย | ✓ | | |
| | ทดสอบการทำงาน (Testing) ของตู้ควบคุมระบบสัญญาณแจ้งเหตุเพลิงไหม้ | | | |
| 16 | ทดสอบการทำงานของหน้าจอแสดงผล (LCD Display) กับแป้นควบคุม (Keypad) | ✓ | | |
| 17 | ทดสอบสถานะของสายไฟแสดงสถานะ (LED Status) ตามแจ้งเตือนต่างๆ | ✓ | | |
| 18 | ทดสอบระบบการควบคุมด้วยตัวตบ (Supervisory) | ✓ | | |
| 19 | ทดสอบสถานะของแบตเตอรี่ (Battery) | ✓ | | |
| 20 | ทดสอบการรีเซ็ตสัญญาณแจ้งเตือน (History Event) | ✓ | | |
| 21 | ทดสอบสถานะของไฟของแบตเตอรี่ และการชาร์จไฟ (Recharge Battery) อัตโนมัติ | ✓ | | |
| 22 | ทดสอบระบบการรับสัญญาณแจ้งเตือนจากอุปกรณ์สัญญาณ (Signal Initiating Device) | ✓ | | |
| 23 | ทดสอบระบบการส่งสัญญาณไปยังงานอุปกรณ์แจ้งเหตุเพลิงไหม้ (Audible Alarm Device) | ✓ | | |
| 24 | ทดสอบการตรวจสอบสถานะแจ้งเตือน (Acknowledge) ที่ตู้ควบคุม | ✓ | | |
| 25 | ทดสอบการรีเซ็ตอุปกรณ์แจ้งเตือน (Reset) ที่ตู้ควบคุม | ✓ | | |

[illegible]

Supporting Member: BRISAN SUBSIDIARY, CHONGQING ZHONGTONG

BRIDGE22 MODA ROMAN SURFATHA, GIOIELLI 2023

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FAX 101 - 0201502005319

การตรวจสอบผู้ควบคุม Fire Alarm Control Panel(No.3)

| ลำดับ | รายการตรวจสอบ | ผ่าน | ไม่ผ่าน | หมายเหตุ |
|-------|--|------|---------|----------|
| 1 | การตรวจสอบสภาพ (Checking) ของตัวควบคุมแรงดันไฟฟ้า (Voltage Regulator) | ✓ | | |
| 2 | ตรวจสอบสายดิน (Grounding) อย่างละเอียด | ✓ | | |
| 3 | ตรวจสอบแบตเตอรี่ (Battery) และวงจรชาร์จ (Charging Circuit) | ✓ | | |
| 4 | ตรวจสอบรีเลย์ (Relay) ควบคุมการชาร์จ (Control Relay) และแก๊ส (Gas) | ✓ | | |
| 5 | ตรวจสอบการจ่ายไฟ (Power Supply) (Transformer Power Supply) | ✓ | | |
| 6 | ตรวจสอบระบบไฟไหม้ (Fire Alarm) และวงจรโทรศัพท์ (Telephone) | ✓ | | |
| 7 | ตรวจสอบสายไฟ ความปลอดภัย (Safety) และวงจรความปลอดภัย | ✓ | | |
| 8 | ตรวจสอบแผงวงจรควบคุม (LCD Display) ที่เห็นการชาร์จ และรีเลย์ (Relay) | ✓ | | |
| 9 | ตรวจสอบการเชื่อมต่อสายไฟ (Wiring) และสายดิน (Grounding) | ✓ | | |
| 10 | ตรวจสอบการเชื่อมต่อสายไฟ (Wiring) และสายดิน (Grounding) และสายดิน (Relay) ด้วย | ✓ | | |
| 11 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 12 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 13 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 14 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 15 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 16 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 17 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 18 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 19 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 20 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 21 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 22 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 23 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 24 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |
| 25 | การตรวจสอบสายไฟ (Cable) ซึ่งมีการเชื่อมต่อแบบถูกต้องและปลอดภัย | ✓ | | |



Received 10 May 2006; accepted 17 July 2006

There is a lot of information in this book, and it is a good idea to read it carefully. The book is written in a clear and concise style, and it is easy to read. The book is a good resource for anyone who is interested in the history of the United States.

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การตรวจเช็คอุปกรณ์

MAGNETIC RECORDING

THE

01473010

1957-1961-1962

| โซน / ส่วนที่ | ประเภทอุปกรณ์ | สถานะ | | หมายเหตุ |
|---------------|---------------------------|-------|---------|-----------------------------|
| | | ปกติ | ผิดปกติ | |
| 11 | Heat Detector | ✓ | | |
| 12 | Heat Detector | ✓ | | |
| 13 | Fixed Temp. Heat Detector | ✓ | | |
| 14 | Fixed Temp. Heat Detector | ✓ | | |
| 15 | Smoke Detector | ✓ | | |
| 16 | Manual Station | ✓ | | |
| 16 | Alarm Bell | ✓ | | |
| 16 | Light | ✓ | | |
| 21 | Smoke Detector | ✓ | | |
| 22 | Smoke Detector | ✓ | | |
| 23 | Smoke Detector | ✓ | | |
| 24 | Smoke Detector | ✓ | | |
| 25 | Manual Station | ✓ | | |
| 25 | Alarm Bell | ✓ | | |
| 25 | Light | ✓ | | |
| 31 | Smoke Detector | ✓ | | |
| 32 | Linear Heat Detector | | | ไม่รวมค่าส่ง อุปกรณ์ป้องกัน |

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TAX ID : 0206020533

รายงานการตรวจเช็คเครื่องใช้ฉุกเฉิน
 EMERGENCY LIGHT CHECK LIST

สถานที่ : บริษัท โกลด์นิ่ม อินดัสทรี (ประเทศไทย) จำกัด (โรงงานระยอง) วันที่ 14 มิถุนายน พ.ศ. 2567

| ลำดับที่ | ชื่ออุปกรณ์ / รายละเอียด | หมายเลขเครื่อง | ชนิดของไฟ | สถานะ | ผลการตรวจ | หมายเหตุ |
|----------|--------------------------|----------------|-----------|-------|-----------|----------|
| | | | | | | |
| 1 | SUNNY / 12V 7Ah | EL-01 | ✓ | ✓ | ✓ | OK |
| 2 | MAX / 12V 5Ah | EL-02 | ✓ | ✓ | ✓ | OK |
| 3 | MAX / 12V 5Ah | EL-03 | ✓ | ✓ | ✓ | OK |
| 4 | MAX / 12V 5Ah | EL-04 | ✓ | ✓ | ✓ | OK |
| 5 | MAX / 12V 5Ah | EL-05 | ✗ | ✗ | ✗ | NG |
| 6 | MAX / 12V 5Ah | EL-06 | ✓ | ✓ | ✓ | OK |
| 7 | MAX / 12V 5Ah | EL-07 | ✓ | ✓ | ✓ | OK |
| 8 | MAX / 12V 5Ah | EL-08 | ✓ | ✓ | ✓ | OK |
| 9 | SUNNY / 12V 7Ah | EL-09 | ✓ | ✓ | ✓ | OK |
| 10 | SUNNY / 12V 7Ah | EL-10 | ✓ | ✓ | ✓ | OK |
| 11 | SUNNY / 12V 7Ah | EL-11 | ✓ | ✓ | ✓ | OK |
| 12 | SUNNY / 12V 7Ah | EL-12 | ✓ | ✓ | ✓ | OK |
| 13 | SUNNY / 12V 7Ah | EL-13 | ✓ | ✓ | ✓ | OK |
| 14 | MAX / 12V 5Ah | EL-14 | ✓ | ✓ | ✓ | OK |
| 15 | SUNNY / 12V 7Ah | EL-15 | ✓ | ✓ | ✓ | OK |
| 16 | MAX / 12V 5Ah | EL-16 | ✓ | ✓ | ✓ | OK |
| 17 | SUNNY / 12V 7Ah | EL-17 | ✓ | ✓ | ✓ | OK |
| 18 | SUNNY / 12V 7Ah | EL-18 | ✓ | ✓ | ✓ | OK |
| 19 | SUNNY / 12V 7Ah | EL-19 | ✓ | ✓ | ✓ | OK |
| 20 | MAX / 12V 5Ah | EL-20 | ✓ | ✓ | ✓ | OK |
| 21 | MAX / 12V 5Ah | EL-21 | ✓ | ✓ | ✓ | OK |
| 22 | SUNNY / 12V 7Ah | EL-22 | ✓ | ✓ | ✓ | OK |
| 23 | MAX / 12V 5Ah | EL-23 | ✓ | ✓ | ✓ | OK |
| 24 | MAX / 12V 5Ah | EL-24 | ✓ | ✓ | ✓ | OK |
| 25 | MAX / 12V 5Ah | EL-25 | ✓ | ✓ | ✓ | OK |
| 26 | MAX / 12V 5Ah | EL-26 | ✓ | ✓ | ✓ | OK |

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TAX ID : 0206020533

การตรวจเช็คอุปกรณ์

สถานที่ตรวจเช็ค : บริษัท โกลด์นิ่ม อินดัสทรี (ประเทศไทย) จำกัด (โรงงานระยอง) วันที่ตรวจเช็ค : 14 มิถุนายน 2567

| โซน / ลำดับที่ | ประเภทอุปกรณ์ | ผลการตรวจ | | หมายเหตุ |
|----------------|----------------|-----------|---------|----------|
| | | ปกติ | ผิดปกติ | |
| 1/1 | Heat Detector | ✓ | | |
| 1/2 | Heat Detector | ✓ | | |
| 1/3 | Heat Detector | ✓ | | |
| 1/4 | Heat Detector | ✓ | | |
| 1/5 | Heat Detector | ✓ | | |
| 1/6 | Heat Detector | ✓ | | |
| 1/7 | Heat Detector | ✓ | | |
| 1/8 | Heat Detector | ✓ | | |
| 1/9 | Heat Detector | ✓ | | |
| 1/10 | Heat Detector | ✓ | | |
| 1/11 | Heat Detector | ✓ | | |
| 1/12 | Heat Detector | ✓ | | |
| 1/13 | Heat Detector | ✓ | | |
| 1/14 | Heat Detector | ✓ | | |
| 1/15 | Heat Detector | ✓ | | |
| 1/16 | Heat Detector | ✓ | | |
| 1/17 | Manual Station | ✓ | | |
| 1/17 | Alarm Bell | ✓ | | |
| 2/1 | Heat Detector | ✓ | | |
| 2/2 | Heat Detector | ✓ | | |
| 2/3 | Heat Detector | ✓ | | |
| 2/4 | Heat Detector | ✓ | | |
| 2/5 | Smoke Detector | ✓ | | |
| 2/6 | Smoke Detector | ✓ | | |
| 2/7 | Alarm Bell | ✓ | | |

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รายงานการตรวจเช็ค เครื่องไฟฉุกเฉิน
EMERGENCY LIGHT CHECK LIST

สถานที่ : บริษัท โลติอุทัยชัย อื่นสกรีน (ประเทศไทย) จำกัด (โรงงานฯ) วันที่ 14 มิถุนายน พ.ศ. 2567

| ลำดับที่ | ชื่อรุ่น/ขนาดแบตเตอรี่ | หมายเลขเครื่อง | แบตเตอรี่ | สภาพไฟ ตามไฟ | หลอดไฟ | | แบตเตอรี่ | หมายเหตุ |
|----------|------------------------|----------------|-----------|-----------------|---------|-------|-----------|----------|
| | | | | | ทั้งชุด | ชำรุด | | |
| 27 | MAX / 12V 5Ah | EL-27 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 28 | MAX / 12V 5Ah | EL-28 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 29 | MAX / 12V 5Ah | EL-29 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 30 | MAX / 12V 5Ah | EL-30 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 31 | MAX / 12V 5Ah | EL-31 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 32 | MAX / 12V 5Ah | EL-32 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 33 | MAX / 12V 5Ah | EL-33 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 34 | MAX / 12V 5Ah | EL-34 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 35 | MAX / 12V 5Ah | EL-35 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 36 | SUNNY / 12V 7Ah | EL-36 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 37 | MAX / 12V 5Ah | EL-37 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 38 | MAX / 12V 5Ah | EL-38 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 39 | MAX / 12V 5Ah | EL-39 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 40 | MAX / 12V 5Ah | EL-40 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 41 | MAX / 12V 5Ah | EL-41 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 42 | MAX / 12V 5Ah | EL-42 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 43 | SUNNY / 12V 7Ah | EL-43 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 44 | MAX / 12V 5Ah | EL-44 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 45 | MAX / 12V 5Ah | EL-45 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 46 | SUNNY / 12V 7Ah | EL-46 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 47 | MAX / 12V 5Ah | EL-47 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 48 | MAX / 12V 5Ah | EL-48 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 49 | MAX / 12V 5Ah | EL-49 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 50 | MAX / 12V 5Ah | EL-50 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |
| 51 | MAX / 12V 5Ah | EL-51 | ✓ | ✓ | ✓ | ✓ | ✓ | OK |

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เลขประจำตัวผู้เสียภาษี : 020564230383 TAX ID : 020564230383



รายงานการตรวจเช็ค เครื่องไฟฉุกเฉิน
FIRE EXIT LIGHT CHECK LIST

สถานที่ : บริษัท โลติอุทัยชัย อื่นสกรีน (ประเทศไทย) จำกัด (โรงงานฯ) วันที่ 14 มิถุนายน พ.ศ. 2567

| ลำดับที่ | ชื่อรุ่น/ขนาดแบตเตอรี่ | หมายเลขเครื่อง | แบตเตอรี่ | สภาพไฟ | หลอดไฟ | หมายเหตุ |
|----------|------------------------|----------------|-----------|--------|--------|----------|
| 1 | MAX / 3.6V 1800 Mah | EX-01 | ✓ | ✓ | ✓ | OK |
| 2 | MAX / 3.6V 1800 Mah | EX-02 | ✓ | ✓ | ✓ | OK |
| 3 | MAX / 3.6V 1800 Mah | EX-03 | ✓ | ✓ | ✓ | OK |
| 4 | MAX / 3.6V 1800 Mah | EX-04 | ✓ | ✓ | ✓ | OK |
| 5 | MAX / 3.6V 1800 Mah | EX-05 | ✓ | ✓ | ✓ | OK |
| 6 | MAX / 3.6V 1800 Mah | EX-06 | ✓ | ✓ | ✓ | OK |
| 7 | MAX / 3.6V 1800 Mah | EX-07 | ✓ | ✓ | ✓ | OK |
| 8 | MAX / 3.6V 1800 Mah | EX-08 | ✓ | ✓ | ✓ | OK |
| 9 | MAX / 3.6V 1800 Mah | EX-09 | ✓ | ✓ | ✓ | OK |
| 10 | MAX / 3.6V 1800 Mah | EX-10 | ✓ | ✓ | ✓ | OK |
| 11 | MAX / 3.6V 1800 Mah | EX-11 | ✓ | ✓ | ✓ | OK |
| 12 | MAX / 3.6V 1800 Mah | EX-12 | ✓ | ✓ | ✓ | OK |
| 13 | MAX / 3.6V 1800 Mah | EX-13 | ✓ | ✓ | ✓ | OK |
| 14 | MAX / 3.6V 1800 Mah | EX-14 | ✓ | ✓ | ✓ | OK |
| 15 | MAX / 3.6V 1800 Mah | EX-15 | ✓ | ✓ | ✓ | OK |
| 16 | MAX / 3.6V 1800 Mah | EX-16 | ✓ | ✓ | ✓ | OK |
| 17 | MAX / 3.6V 1800 Mah | EX-17 | ✓ | ✓ | ✓ | OK |



บริษัท มิรา เซฟตี้ เซอร์วิส แอนด์ ซัพพลาย จำกัด (จำกัดความรับผิด)
 890332 หมู่ 3 ตำบลบ้านใหม่ อ.บึงสามพัน จ.พิจิตร 36130
 โทร : 055-7252359, 055-9802771 ต่อ : 10101 - 10106 Email : mirasafety@mirasafety.com
 บริษัท มิรา เซฟตี้ เซอร์วิส แอนด์ ซัพพลาย จำกัด (จำกัดความรับผิด)
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การตรวจเช็คอุปกรณ์ ผู้เก็บสายเคเบิลเคเบิล

สถานที่ตรวจเช็ค : บริษัท มิรา เซฟตี้ เซอร์วิส แอนด์ ซัพพลาย จำกัด (จำกัดความรับผิด)
 วันที่ตรวจเช็ค : 14 มิถุนายน 2567

| ลำดับ | รายการที่ตรวจเช็ค | จำนวน | ผลการตรวจเช็ค | | หมายเหตุ |
|---------------------|------------------------|-------|---------------|---------|----------|
| | | | ปกติ | ผิดปกติ | |
| PHC.1 (เจ้าหน้า) | Fire Hose 2 1/2" | 1 | ✓ | | |
| | Hose Gate Valve 2 1/2" | 1 | ✓ | | |
| | Fire Hose Cabinet | 1 | ✓ | | |
| PHC.2 (เจ้าหน้า) | Fire Hose 2 1/2" | 1 | ✓ | | |
| | Hose Gate Valve 2 1/2" | 1 | ✓ | | |
| | Fire Hose Cabinet | 1 | ✓ | | |



บริษัท มิรา เซฟตี้ เซอร์วิส แอนด์ ซัพพลาย จำกัด (จำกัดความรับผิด)
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การตรวจเช็คอย่างถึงตามหลัก

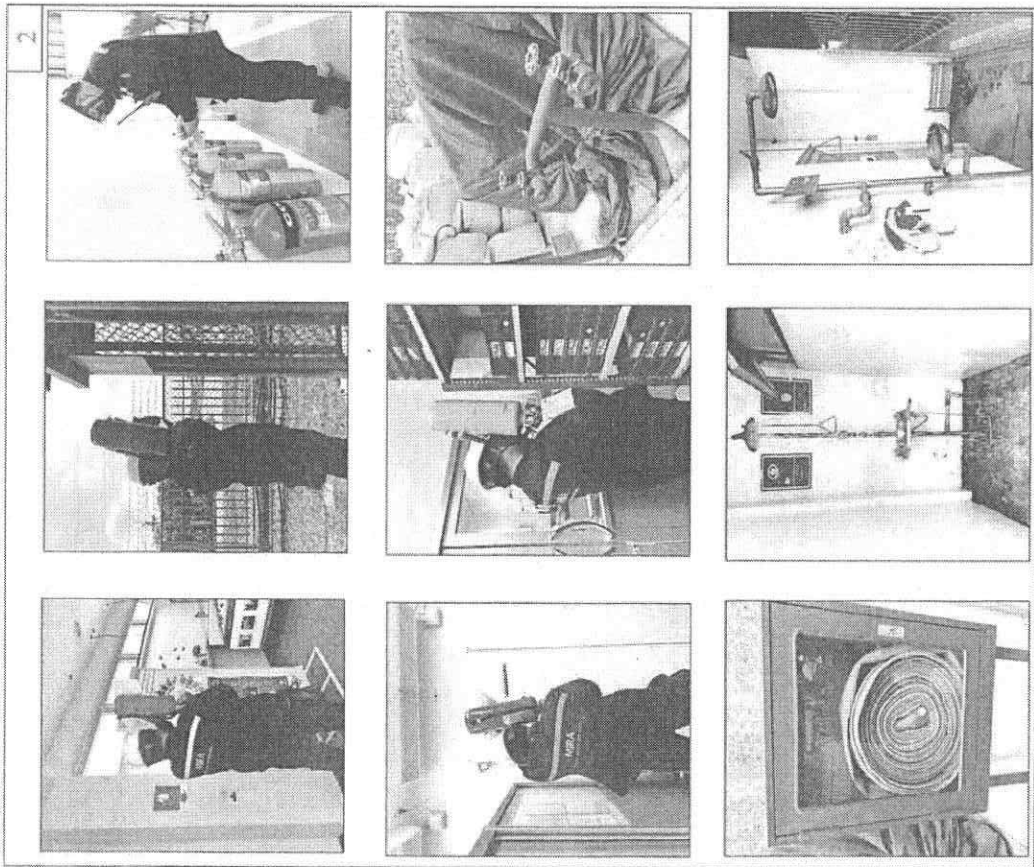
สถานที่ตรวจเช็ค : บริษัท มิรา เซฟตี้ เซอร์วิส แอนด์ ซัพพลาย จำกัด (จำกัดความรับผิด)
 วันที่ตรวจเช็ค : 14 มิถุนายน 2567

| ลำดับ | รายการที่ตรวจเช็ค | จุดที่ 1 | จุดที่ 2 | หมายเหตุ |
|-------|---|----------|----------|----------|
| 1 | เบรคมือรถจักรยานยนต์ 1 คันที่จอดอยู่หน้าประตูหน้า | ✓ | ✓ | |
| 2 | ตัวถังรถจักรยานยนต์ 1 คันที่จอดอยู่หน้าประตูหน้า | ✓ | ✓ | |
| 3 | ล้อรถจักรยานยนต์ 1 คันที่จอดอยู่หน้าประตูหน้า | ✓ | ✓ | |
| 4 | ไม่มีร่องรอยการชำรุดเสียหาย | ✓ | ✓ | |
| 5 | ชุดถังดับเพลิง 1 ชุดที่ติดตั้งอยู่หน้าประตูหน้า | ✓ | ✓ | |
| 6 | ชุดถังดับเพลิง 1 ชุดที่ติดตั้งอยู่หน้าประตูหน้า | ✓ | ✓ | |
| 7 | ชุดถังดับเพลิง 1 ชุดที่ติดตั้งอยู่หน้าประตูหน้า | ✓ | ✓ | |
| 8 | ไม่มีร่องรอยการชำรุดเสียหาย | ✓ | ✓ | |
| 9 | วาล์วเปิด-ปิด มีสัญญาณไฟแจ้งเตือน | ✓ | ✓ | |
| 10 | วาล์วเปิด-ปิด มีสัญญาณไฟแจ้งเตือน | ✓ | ✓ | |
| 11 | วาล์วเปิด-ปิด มีสัญญาณไฟแจ้งเตือน | ✓ | ✓ | |
| 12 | ไม่มีร่องรอยการชำรุดเสียหาย | ✓ | ✓ | |
| 13 | ผลการตรวจเช็คทั้งหมด | ✓ | ✓ | |

สถานที่ตรวจเช็ค : บริษัท มิรา เซฟตี้ เซอร์วิส แอนด์ ซัพพลาย จำกัด (จำกัดความรับผิด)
 วันที่ตรวจเช็ค : 14 มิถุนายน 2567



บริษัท มิรา เซอร์วิส เซอร์วิสเซส จำกัด (มหาชน)
 88/332 หมู่ 3 ถนนมิตรภาพ อ.เมือง จ.ขอนแก่น 40000
 โทร : 053-1201991, 053-8862771 ต่อ 6-608 | miral-service.com
 บริษัท มิรา เซอร์วิส เซอร์วิสเซส จำกัด (มหาชน)
 88/332 หมู่ 3 ถนนมิตรภาพ อ.เมือง จ.ขอนแก่น 40000
 โทร : 053-1201991, 053-8862771 ต่อ 6-608 | miral-service.com
 TAX ID : 01054000035



| | | | |
|--|------------------------|-----------|-------------|
| บริษัท มิรา เซอร์วิส เซอร์วิสเซส จำกัด | | | |
| DARK ALUMINUM INDUSTRY (THAILAND CO., LTD. RAYONG PLANT) | EXISTING TITLE: | DESIGN | DRAWING NO. |
| | FIRE PROTECTION SYSTEM | UNCHECKED | FA-01 |
| | AREA: | | DATED |
| | ALL PLANT | | 2024-2025 |
| | | | REVISION: |
| | | | 6 |

| | | | | | | | | | | | | |
|---|--|--|--|--|---|--|------------------------|--|---------------|--|---------------|--|
| <div></div> | | | | | | | | | | | | |
| | | | | | PROJECT NAME : | | DRAWING TITLE : | | DRAWN : | | DRAWING NO. : | |
| | | | | | DAIKI ALUMINUM INDUSTRY (THAILAND) CO., LTD. (RAYONG PLANT) | | FIRE PROTECTION SYSTEM | | W. MANASSAWEE | | FE-01 | |
| บริษัท มิตรา เซฟตี้ เซอร์วิสเซส แอนด์ ซัพพลาย จำกัด | | | | | AREA : | | CHECKED : | | DATED : | | REVISION : | |
| | | | | | ALL PLANT | | W. PRADUM | | 2024-2025 | | | |

| | | | | | | | | | | | | |
|---|--|--|--|--|---|--|------------------------|--|-----------|--|---------------|--|
| <div></div> | | | | | | | | | | | | |
| | | | | | PROJECT NAME : | | DRAWING TITLE : | | DRAWN : | | DRAWING NO. : | |
| | | | | | DAIKI ALUMINUM INDUSTRY (THAILAND) CO., LTD. (RAYONG PLANT) | | FIRE PROTECTION SYSTEM | | | | EL-01 | |
| บริษัท มิตรา เซฟตี้ เซอร์วิสเซส แอนด์ ซัพพลาย จำกัด | | | | | AREA : | | CHECKED : | | DATED : | | REVISION : | |
| | | | | | ALL PLANT | | | | 2024-2025 | | 8 | |