MARSH

LEADERSHIP, KNOWLEDGE, SOLUTIONS...WORLDWIDE.

INSPECTION TESTING MAINTENANCE

WATER BASED FIRE PROTECTION SYSTEMS

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MARSH & McLENNAN COMPANIES

ITM ?

video

WHY IS ITM NECESSARY?

1. All other barriers have failed. The fire protection system is you last Line of Defense (LoD)*
2. OGP: 80% of all systems do not provide anticipated performance when activated
3. That is why NFPA uses ITM to secure ≥99%* availability* and reliability*
4. ITM also provides the tool to prove 99% availability and reliability

EXPLANATORY SLIDE (1)

Reversed reasoning

- Layers of Protection Analysis
- Safety Integrity Level

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- Last LoD
- Availability & Reliability of ≥99 % (at least SIL 2) is conditional

EXPLANATORY SLIDE (2)

Availability:

- (Redundancy) incorporated in the design phase
- Established by implementing ITM
- Proven by record keeping and calculations

8760 hours/year (also leap year)
Hours of non-availability with ≥20 minutes is [X]

Availability = $\frac{[8760 - X] * 100}{8760}$ = availability%

EXPLANATORY SLIDE (3)

Reliability:

- Design and redundancy incorporated in the design
- Organization
- Storage conditions
- Stored product
- Weather conditions
- ITM

NFPA & ITM (1)

- NFPA advises
- ITM should not be used for review of the design!
- Almost all water based NFPA codes and standards contain ITM relevant information
- NFPA 11 (chapter 5) and NFPA 30 (chapter 22) list information relevant for fire protection of storage tanks
- NFPA 25: *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection systems* is fully dedicated to ITM

NFPA & ITM (2)

- Use NFPA 25 together with:
  - Codes and standards used for the design of the system
  - NFPA 25 Handbook
  - NFPA 3: Recommended Practice for Commissioning and Integrated Testing of Fire Protection and Life Safety Systems
  - Commissioning and Integrated System Testing Handbook

NFPA & ITM (3)

NFPA 25

- Useful but does not provide detailed information for fire protection systems at industrial sites / storage tanks
- The comprehensive document is applicable and leads the user through the process to setup and implement the ITM regime.

NFPA 25 (1)

Scope NFPA 25:

- 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.
- The scope of NFPA 25 is intended to help users determine if they are using the correct standard.

NFPA 25 (2)

NFPA 25 contains the minimum requirements for the inspection, testing, and maintenance of a water-based system to ensure the system performs properly. It also contains requirements for investigating and addressing *changes that occur to a building* [or construction]*, its use, or water supply and the potential impact on the water-based systems*. The minimum requirements specified in NFPA 25 must be met in order for a system to comply with this standard.

NFPA 25 (3)

Nothing in the standard is intended to prevent more frequent or more extensive inspection, testing, and maintenance activities if the level of safety or performance of the system is at stake, or if the owner would like a more comprehensive assessment of the fire protection systems in a particular building.

Section 4.7 permits alternative means of compliance using a performance based program that could result in less frequent inspection, testing, and maintenance activities.

PRINCIPLES PERFORMANCE BASED SETUP (1)

The concept of a performance-based testing and inspection program is to establish the requirements and frequencies at which inspection must be performed to demonstrate an acceptable level of operational reliability. The goal is to balance the inspection/test frequency with proven reliability of the system or component. The goal of a performance-based inspection program is also to adjust test/inspection frequencies *commensurate* with historical documented equipment performance and desired reliability. Frequencies of test/inspection under a performance-based program can be extended or reduced from the prescriptive test requirements contained in this standard when continued testing has been documented indicating a higher or lower degree of reliability compared to the authority having jurisdiction's expectations of performance.

PRINCIPES PERFORMANCE BASED SETUP (2)

Fundamental to implementing a performance-based program is that adjusted test and inspection frequencies must be technically defensible to the authority having jurisdiction and supported by evidence of higher or lower reliability. Data collection and retention must be established so that the data utilized to alter frequencies are representative, statistically valid, and evaluated against firm criteria. Frequencies should not arbitrarily be extended or reduced without a suitable basis and rationale. It must be noted that transitioning to a performance based program might require *additional expenditures of resources* in order to collect and analyze failure data, coordinate review efforts, replace program documents, and seek approval from the authority having jurisdiction.

EQUIVALENCE

1.3.1 It is not the intent of this document [NFPA 25] 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 document.

DEFINITION

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

EXPLANATORY NOTES

- 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 departmental official may be the authority having jurisdiction.

DEFINITION

3.2.4 Shall
Indicates a mandatory requirement.

3.2.5 Should
Indicates a recommendation or that which is advised but not required.

DEFINITION

3.3.29 Performance-Based Program. Methods and frequencies that have been demonstrated to deliver equivalent or superior levels of performance through quantitative performance-based analysis.

SETUP & IMPELMENTATION ITM

- ITM with associated procedures, instructions, checklists, log books, etc. are part of the Safety Management System
- Aims and goals of ITM should be set against accepted codes/standards or reference documents
- Frequencies for inspection, testing maintenance are determined and listed
- List events for which non-planned ITM shall be performed
- ITM shall be executed by competent personnel only

DEFINTION

3.3.34 Qualified

A competent and capable person or company that has met the requirements and training for a given field acceptable to the AHJ. [96, 2014]

EXECUTING ITM

- Record findings (report, photos, videos)
- Evaluate findings – are they correct, complete, compliance with ITM frequencies, …
- Classify deviations as critical or non-critical
- Procedure for addressing critical deviations immediately
- Determine when non-critical deviations have to be resolved
- Monitor/follow-up & review/audit performed work

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INSPECTIONS (1)

- Visual - rounds as well as supervision of work
- Inspection - construction, installations, technical/organizational provisions
- Accredited inspection bodies
- Inspection of procedures and documents
- Inspection by off-site installer/maintenance company

MARSH 22

INSPECTIONS (2)

- Inspection critical components like supports, fire water system valves, …
- Inspection as part of acceptance test (NFPA 3)
- Inspection combined with testing, like operability of valves
- Theme inspections, like winterizing related inspections

MARSH 23

TESTING (1)

- Acceptance test(s)
  Definition:
  Tests performed at the completion of installation to confirm compliance with applicable manufacturers' installation specifications, applicable codes and standards, and the project BOD and OPR
- Retro-acceptance test:
  Is carried out on an existing installation

  BOD: Basis of Design
  OPR: Owners Project Requirements

MARSH 24

TESTING (2)

- **Integral test** = detection + extinguishment + cooling combined
  More than one integral test may be relevant for the system
- Definition integral test**:**
  Life test to review performance (coordination, interaction, expediency and functionality), by observation, measurements, monitoring, etc., of all individual fire protection installations together that have a function in the control of the incident scenario

MARSH 25

TESTING (3)

- First (integral) acceptance test provides
  Base values = reference for future ITM test results
- Periodic integral tests
  - 1 x per 10 years or other frequency (AHJ) during turnaround
  - After changes were made to tank, different product, different foam type, different application rate and/or new insights about the scenario

MARSH 26

TESTING (4)

- Relation between integral test and ITM
  - Integral test → installation/system performance at time X
  - Integral test does not provide info about the condition of the installation/system
  - ITM provides info about the condition of the installation/system
- Testing of critical components
  Critical component = component which function is critical for good performance of installation

MARSH 27

MAINTENANCE

- Preventive maintenance critical components. Frequency based on:
  - Conditions/info producer/supplier
  - Codes/standard like NFPA
  - Experience
  - Risk analysis

  Always apply highest frequency
- Unanticipated – after inspection/testing
- Breakdown, interference, impairment, …

MARSH 28

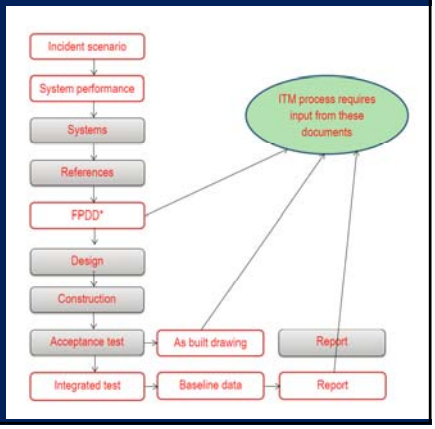
ROLE OF VAN CERTIFICATES IN ITM

- System certificate – ISO 17020: *Conformity assessment Requirements for the operation of various types of bodies performing inspection*
- Maintenance certificate
- Certificates of installation part by manufacturers or suppliers
  - Foundations for certificate
  - Used principles relevant for operational conditions
  - Management system producer/supplier to secure quality anticipated by certificate

MARSH 29

PERFORMANCE BASED ITM

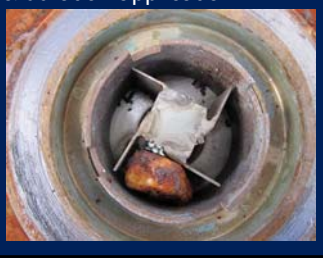
*FPDD=
Fire Protection
Design
Document



MARSH

ROLE OF INDIVIDUAL DOCUMENTS (1)

- FPDD (conditional)
  - Involved substances and scenarios
  - Performance criteria (detection, water, foam)
  - Application l/min/m^2 & duration application
  - Foam expansion
  - Water quality
  - Water hardness
  - References



MARSH 31

ROLE INDIVIDUAL DOCUMENTS (2)

- As built drawing - P&ID installations/system
  Essential for identification critical components
- Report with results of integral test acceptance test – base findings and values for all future tests and a reference to be used in finding the cause of non compliance of the installation/system

MARSH 32

STORED SUBSTANCES

• Mixture	burning behavior application rate
• Heated products	o-cresol; benzoic acid condensation, solids
• Heated >100°C	formation of steam

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STORED LIQUID BECOMES A SOLID

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STORED SUBSTANCES (continued)

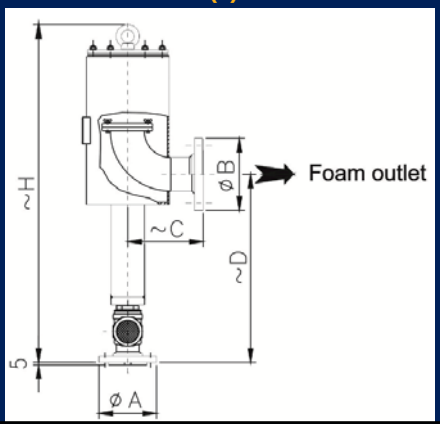
• Polymerization	Vinyl Acetate; Styrene; Acrylates
• Corrosives	Acetic acid, Amines material choice
• Organic peroxides	use water not foam
• Water soluble liquid	suitability foam
• Specific gravity	higher/lower than water

MARSH 35

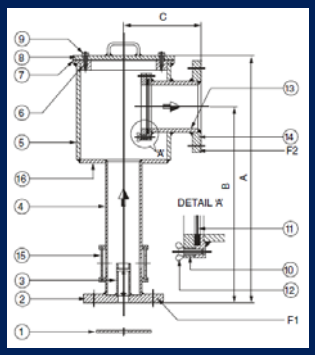
DESIGN FOAM POURER

- Frangible disc can be compromised
- Compatibility of materials sealant of the frangible disc as it can be compromised by the solvent's vapors

FOAM POURER DESIGN (1)



FOAM POURER DESIGN (1)



HEATED/POLYMERISED SUBSTANCES

INCORPORATE ITM IN THE DESIGN PHASE (1)

NFPA 16: *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*

9.1.1 Systems shall be so arranged that tests and inspections can be made without discharging foam solution to the system piping in order to check Operation of all mechanical and electrical components of the system.

9.1.2 The system shall be arranged so that tests are performed with as little loss of foam concentrate as possible.

"Shall" is mandatory!

INCORPORATE ITM IN THE DESIGN PHASE (2)

- Costs are usually ≤1‰ of total costs while the benefits are significant
- Accessibility of installations and components
- Consider safety of persons carrying out ITM

COUPLINGS NEAR SUPPORTS

SLOPING?

MARSH

WATER ⇔ OBSTRUCTIONS/GASKETS/SEALS

MARSH 43

PIPES & TESTING ⇔ WATER

- Carbon steel and GRE pipes, together with their supports, each have their own specific criteria for inspection, testing and maintenance

  Manufacturer of GRE provides the ITM criteria.

- Water quality (fresh water, salt/brackish water, cooling water, etc.) affects ITM frequencies

MARSH 44

ITM WATER COOLING TANK SAFETY ALERT

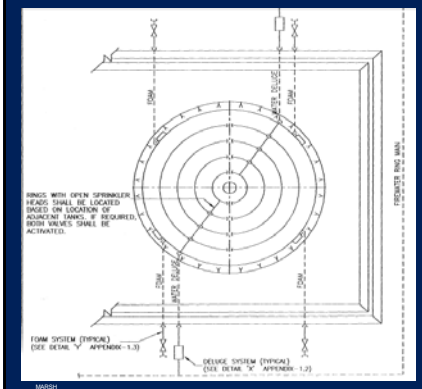
VERIFY INBREATHING CAPACITY OF STORAGE TANK MEETS REQUIREMENTS OF API 2000 BEFORE INSTALLATIONS FOR COOLING STORAGE TANKS ARE TESTED DURING A HOT SUMMER'S DAY

ITM COOLING SYSTEMS (1)

EXPOSURE PROTECTION

10 l/min/m^2

ITM COOLING SYSTEMS (2)



SECTIONS CAN BE ACTIVATED INDIVIDUALLY

ITM COOLINGS SYSTEMS (3)

TOP COOLING

ITM COOLING SYSTEMS (4)

COOLING CYLINDER

2 l/min/m^2

WHAT IS THE SCENARIO & PURPOSE OF COOLING

CASE STUDY

1	4	7
2	5	8
3	6	9

CASE STUDY (continued)

- 9 non-insulated carbon steel tanks with cone roof and weak seam in concrete bund (165 x 165 m)
- All tanks contain gasoline
- Diameter of tanks is 33 meter and height is 22 meter
- Distance between tanks and bund is ½ tank diameter
- No Nitrogen blanketing, no ERV
- Top tank cooling
- Net surface bund = 20,385 m^2 (27,225 - 8 x 855 m^2)

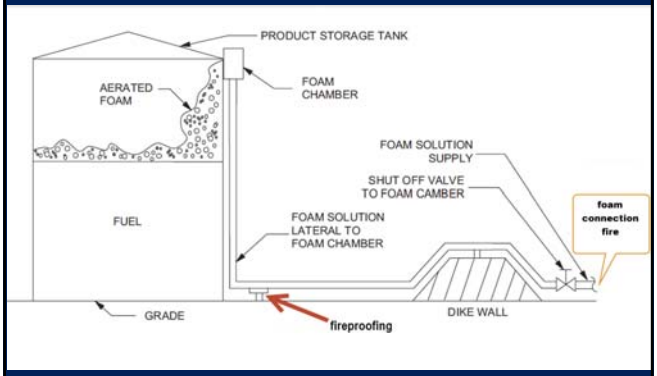
CASE STUDY (continued)

- Full surface tank fires are extinguished with fixed foam system application rate 4.1 l/min/m^2
- Bund fires are extinguished with fixed foam system application rate 4.1 l/min/m^2 supplied to fire
- LEL detection present in bund
- Cooling on tank is activated by Polyflow application rate 2 l/min/m^2 – **no dry spots!**
- 7 remotely activated hydroshields at one site of the bund wall are present – each 1, 200 l/min (span 25 meter)

CASE STUDY (continued)

- The foam and cooling water lines are made from GRE
- Foam is supplied to the foam systems by the fire department from manifolds at both sides of the bund
- The supports of these lines through the bund are elevated and therefore have fire proofing

CASE STUDY (drawing foam system)



CASE STUDY (continued)

- Brackish surface water is used for cooling of the tanks and fire fighting foam
- Static foam system on each tank designed for full surface tank fire.
  Fire department supplies the foam system from safe location with 4.1 l/min/m^2 with premix (3% foam).

AVAILABLE INFORMATION (1)

- Report of acceptance tests are available for:
  - Fire water supply and fire water main while 3 adjacent hydrants are operation at full capacity at a pressure of 10 bar
  - Cooling water system bund while 9 tanks are cooled at the same time – **no dry spots!**

Water Flow:
$9 \times ((0.25 \times \pi \times 33^2) + (\pi \times 33 \times 22)) \times 2 = 56{,}430$ l/min

9 tanks x (roof m^2 + cylinder m^2) x application rate l/min/m^2

AVAILABLE INFORMATION (2)

Report of acceptance tests are available for:
- Full surface tank fire tests of tank 5 while all 8 surrounding tanks (1, 2, 3, 4, 6, 7, 8, 9) are cooled – main pressure is 10 bar

Flows

Premix	$(0.25 \times \pi \times 33^2 \times 4{,}1) = 3{,}506$ l/min
Water	$0{,}97 \times 3{,}506 = 3{,}401$ l/min extinguishment
Foam	$0{,}03 \times 3{,}506 = 105$ l/min
Water	$8 \times 3{,}135 \times 2 = 50{,}160$ l/min cooling 8 tanks

Total water demand 53,561 l/min or 3,214 m^3/hr

AVAILABLE INFORMATION (3)

- Bund fire – while all tanks are cooled and main pressure is 7 bar

Flows:

Premix	$20{,}385 \times 4.1 = 83{,}579$ l/min
Water	$0{,}97 \times 83{,}579 = 81{,}071$ l/min extinguishment
Foam	$0{,}03 \times 83{,}579 = 2{,}507$ l/min
Water	$56{,}430 + 8{,}400 = 64{,}830$ l/min cooling 9 tanks and 7 hydroshields

Total water demand 145,901 l/min or 8,745 m^3/h

ITM SUPPORTS (1)

poor design/construction

supports with fire proofing

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ITM SUPPORTS (2)

Similar or not?

MARSH

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NO EXPLANATION REQUIRED

MARSH 63

DRAINS

DESIGN

ACCESSIBILITY

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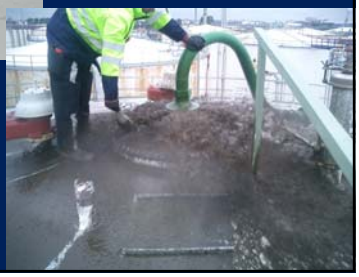
AUTOMATIC DRAINS FAIL TO CLOSE

MARSH 65

TOP TANK COOLING



FLUSHING

MARSH

DEFLECTOR PLATE

MARSH 67

POSITION FRANGIBLE DISK

MARSH 68

TESTING FOAM POURER WITH WATER

MARSH 69

QUESTIONS

MARSH 70

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