Interreg Baltic Sea Region

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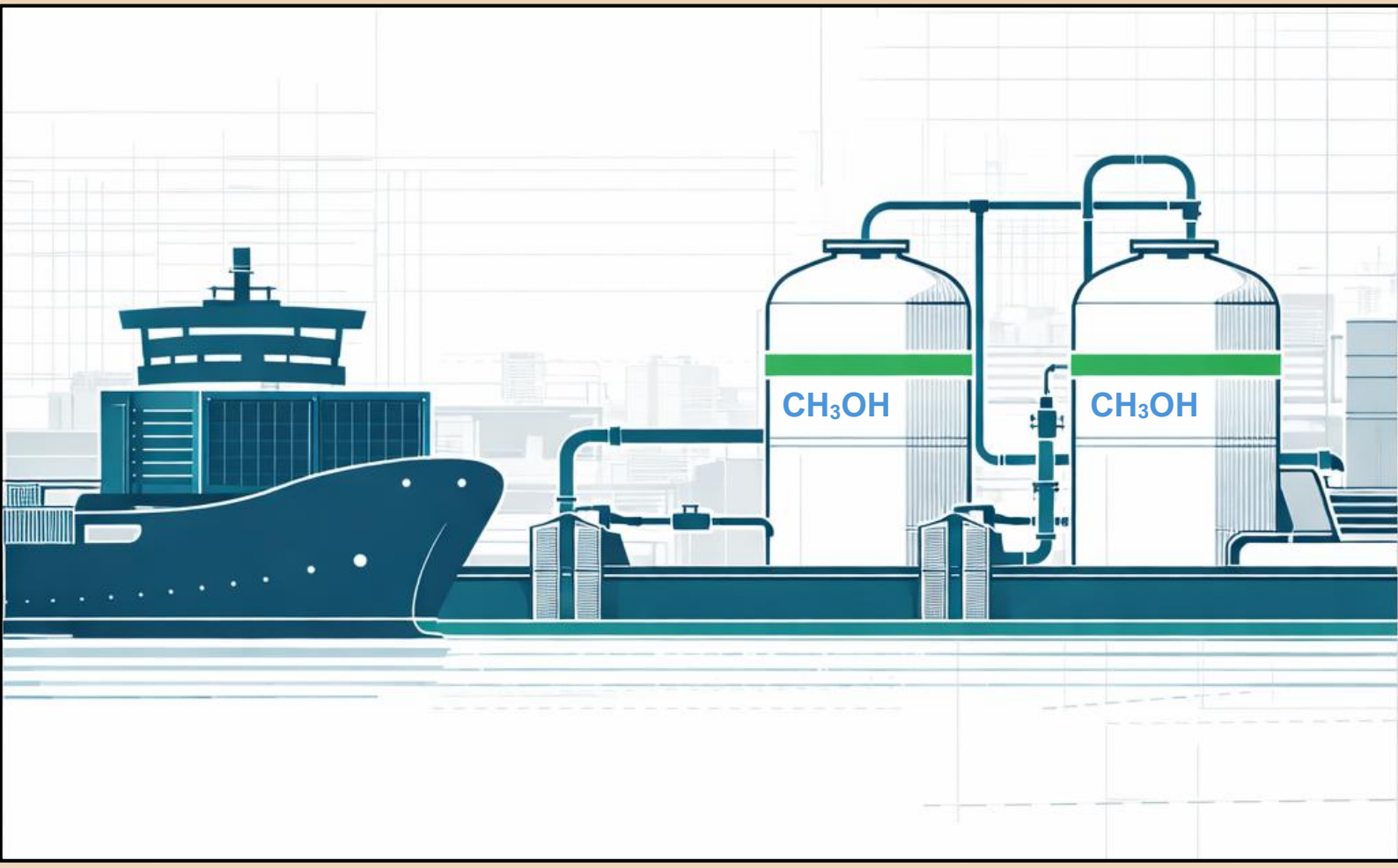
ENERGY TRANSITION H2Deri@BSP

METHANOL IN PORTS

HANDBOOK



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1 Introduction

1.1 Methanol as Marine Fuel - Enabling Maritime Decarbonization:

Shipping is the sixth largest CO_2 emitter worldwide, with CO_2 emissions of 700 million tons per year, accounting for 3% of total global CO_2 emissions. In addition, the total amount of CO_2 emissions related to shipping is still rising (see Fig. 1). To initiate a transformation, alternative fuels are needed, and one of the most promising candidates, which can reduce emissions by up to 95% compared to fossil fuels, is methanol. Once methanol is produced from renewable sources, such as e-methanol from green hydrogen and captured CO_2 or bio-methanol from biomass, it can be an almost completely climate-neutral fuel.

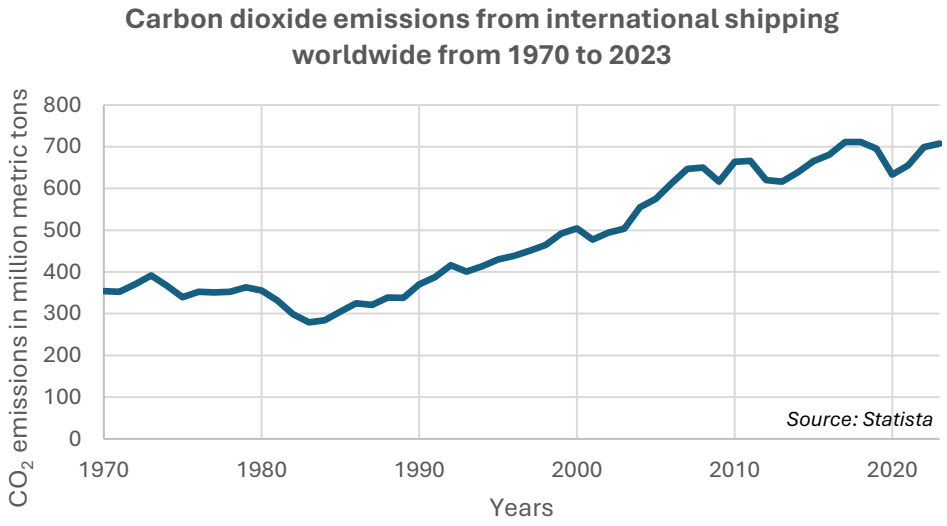

Fig. 1: Development of yearly CO_2 Emissions by global shipping

The development of methanol-powered ships has already begun, with almost 500 methanol-compatible ships in service in February 2026. The major advantages of methanol include its liquid state under normal conditions, its compatibility with modified conventional engines, and the already established global production and transport infrastructure. Due to the need for alternative fuels within the maritime sector, methanol will play a central role in the decarbonization of shipping.

1.2 Purpose and how to use this document

This manual serves as a guide for port authorities, terminal operators, and port companies planning to use or store methanol within the port and providing an overview of relevant steps and international standards to be considered (e.g. Seveso-III, EN, and best practices). The handbook is divided into nine categories covering the installation of a methanol storage facility, the handling of methanol in the port area, and the protection of facilities against external influences.

The regulatory framework emphasizes that the specific challenges involved in handling methanol in ports, particularly due to its high toxicity, flammability, and water solubility require special knowledge and increased safety measures compared to conventional petroleum facilities. It is intended as a planning and compliance tool and does not replace the technical and detailed special requirements at individual port locations. In addition to this manual, users should identify applicable measures and consult the referenced standards for further details. Port facilities implementing methanol operations should view this framework as a foundation for developing site-specific procedures and safety management systems that protect workers, the public, and the environment while enabling efficient and reliable fuel supply operations.

In addition to measures relating to the construction of new methanol-compatible tanks, measures for converting other tanks to methanol-compatible tanks are also described. This is common practice, as methanol is compatible with many atmospheric EN 14015 tanks designed for compatible liquids (e.g., gasoline, biofuels). These conversion measures are marked in purple and consist mainly of three main measures (MX01 – MX03). They include a checklist for checking the necessary structural conditions, material compatibility and modification, and commissioning.

Further, all other measures must also be fulfilled, unless otherwise specified; these exceptions are also marked in purple. Many of the new construction measures should already be fulfilled for existing tanks, but it is nevertheless advisable to take the complete set of measures into account during conversion and to verify them through site-specific risk assessments.

1.3 Methanol in a nutshell

Methanol (CH_3OH), also known as methyl alcohol, is an important chemical feedstock and emerging marine fuel with special handling characteristics. It is a clear, colorless

liquid at normal conditions with a distinctive alcohol odor and presents specific hazards:

- **Flammability**:
  - Methanol is a highly flammable liquid and can be ignited at vapor concentrations between 6 Vol.-% (LEL) and 36 Vol.-% (UEL)
  - Spontaneous combustion occurs at 440 °C. The flash point is comparatively low at 9 °C.
  - Methanol burns with a barely visible bluish flame. Flame detectors are therefore necessary and provide early warning.
- **Toxicity**:
  - Methanol is toxic. It attacks certain organs and the central nervous system, which can lead to long-term damage or death. Symptoms can include coughing, headaches, dizziness, nausea, or visual disturbances. Methanol is easily absorbed through all routes of exposure, including the skin.
- **Water Solubility**:
  - Methanol is 100% miscible with water. Special measures are required in the event of spills.
  - Different containment strategies than for hydrocarbons are needed.
- **Vapor Behavior**:
  - Methanol is slightly heavier than air (vapor density 1.11). It accumulates in low-lying areas and can create explosion hazards in confined spaces.

Strict safety regulations and special equipment are required for the safe storage and handling of methanol in ports.

2 Regulatory Measures

Overview of Measure Chapters

1	**Site planning and infrastructure safety**
	Physical location, layout, access control, and basic infrastructure requirements
2	**Storage Tank Design and Construction**
	Tank specifications, materials, structural requirements, and protection systems
3	**Safety Systems and Instrumentation**
	Control systems, monitoring, protective devices, alarms, and safety instrumentation
4	**Product Handling and Transfer Systems**
	Piping, loading/unloading equipment, material compatibility, and transfer operations
5	**Operational Procedures and Controls**
	Operating procedures, training, process control, and quality management
6	**Detection and Monitoring Systems**
	Gas detection, leak detection, environmental monitoring, and alarm systems
7	**Inspection, Maintenance and Testing**
	Periodic inspection requirements, maintenance programs, and testing protocols
8	**Emergency Preparedness and Response**
	Emergency plans, protective equipment, firefighting, and crisis management
9	**Modern Requirements**
	Cybersecurity, climate resilience, physical security threats, and sustainability

2.1 Site Planning and Infrastructure Safety

Scope: Physical location, layout, access control, and basic infrastructure requirements

M1: Site Selection and General Facility Planning

- The methanol storage facility location selected based on assessment of proximity to residential areas, public roads, fire services, and emergency response capabilities.
- Topography, prevailing wind direction, and environmental factors (flood risk, groundwater, soil conditions) evaluated and documented.
- Site layout ensures minimum separation distances from adjacent facilities per national regulations.
- Facility accessible by emergency vehicles with adequate turning radii.
- Groundwater protection assessment and soil permeability testing conducted before construction.

Note: Methanol vapors are heavier than air and travel along the ground following wind patterns.

M2: Collision Protection and Vehicle Safety

- Storage tanks, loading equipment, pumps, and critical piping protected against vehicle collision through bollards, guardrails, or concrete barriers.
- Barriers designed to withstand impact from heaviest expected vehicles.
- Minimum clearance 1.5-3 meters maintained between traffic routes and process equipment.
- Speed limit maximum 15 km/h in tank farm and loading areas.

M3: Perimeter Security and Access Control

- Facility area secured with fencing minimum 1.8 meters height.
- Access gates equipped with locks.

- Perimeter marked with hazard signage:
  - Globally Harmonized System (GHS) pictograms (H225, H301, H311, H331, H370)
  - "FLAMMABLE LIQUID - TOXIC IF SWALLOWED/INHALED/SKIN CONTACT – DAMAGES ORGANS" warnings
  - Signage in local language(s) and English
- Minimum two separate entrances accessible for emergency services at all times.
- Escape routes clearly marked and maintained unobstructed.

M4: Emergency Access Routes

- All storage tanks, loading areas, and critical equipment accessible via minimum two independent roadways.
- Emergency access roads minimum 6 meters width with minimum turning radius 12 meters.
- Road load-bearing capacity minimum 16 tons axle load.
- Clear height minimum 4.5 meters for overhead obstructions.
- No parking, storage, or equipment placement on emergency access routes.
- Minimum two sides of each storage tank accessible for firefighting operations.

M5: Safety Distances - Heat Radiation and Fire Protection

- Separation distance maintained from buildings and structures with fire risks to keep methanol facilities below 10 kW/m^2 thermal radiation exposure (based on worst-case pool fire scenarios identified in the safety assessment).
- Heat radiation distances shall be determined by quantitative risk assessment using recognized fire radiation models, in line with applicable European / national regulations and guidance (e.g. TRGS 509 and industry guidance such as EIGA Doc 75/21 or equivalent).
- If separation distance is not achievable:
  - Thermal barriers or fire-resistant walls (minimum 2-hour fire rating, equivalent to REI 120 according to EN 13501-2).
  - Water spray/deluge cooling systems (minimum 10 L/min/m^2).
  - Reflective white or aluminum paint on tank surfaces.

Note: Methanol burns with nearly invisible, pale blue flame; fire detection relies on thermal radiation and smoke.

M6: Safety Distances - Pressure Storage Protection

- Methanol atmospheric storage requires minimum separation per local risk assessment (typically 100-150 m) from high-pressure storage vessels (>150 m^3).
- Risk assessment includes vessel rupture, projectile hazards, and blast effects.

M7: Internal Facility Spacing

- Minimum 10 meters separation between storm drains, sewers, and methanol loading/unloading areas.
- All drains within 15 meters of methanol areas equipped with vapor traps, liquid seals, or sealed covers.
- Below-grade spaces (pits, basements, cable trenches) within 15 meters of methanol operations must be vapor-sealed or continuously ventilated with gas detection.
- Incompatible materials storage (oxidizing agents, strong acids) physically separated minimum 15 meters or by fire-rated barrier.

  Note: Methanol vapors heavier than air (vapor density 1.11) and accumulate in low-lying areas.

M8: Spill Containment and Environmental Protection

- Secondary containment required around all above-ground methanol storage tanks.
- Containment capacity minimum 110% of largest tank volume plus firefighting water (typically 10 L/min/m^2 tank surface for 4 hours).
- Construction: impermeable concrete, plastic-lined earthen (High-Density Polyethylene (HDPE) minimum 1.5mm), or welded steel; minimum wall height 1 meter above maximum liquid level.
- Floor sloped toward collection sump (maximum 1% slope) with leak detection and level monitoring.
- Drain valves normally closed and locked; drainage only after visual and chemical verification (no methanol present).
- Contaminated water sent to treatment system or licensed disposal; discharge limits per local regulations (typically <1 mg/L methanol).
- Monthly visual inspection; annual integrity testing; documentation maintained minimum 10 years.

Note: Methanol is 100% water-miscible; all collected liquids treated as contaminated until proven otherwise.

M9: Drainage and Wastewater Treatment System

- Segregated drainage system:
  - Process area drains: collect potential methanol contamination
  - Clean area drains: collect uncontaminated rainwater
  - No cross-connection permitted
- Process drainage:
  - Drain design prevents vapor escape (liquid seals minimum 15 cm depth or sealed covers)
  - Collection sump with level monitoring and high-level alarm
  - Sump pump capacity minimum 2×maximum of anticipated inflow rate
- Wastewater treatment: on-site biological treatment or licensed disposal facility.
- Effluent monitoring for methanol concentration before discharge.
- Emergency provisions: temporary storage capacity and portable pumping equipment available.
- Documentation: as-built drawings, monthly analysis records, annual system review.

M10: Tank Truck Loading Area - Distance from Property Boundary

- Minimum 15 meters separation between loading area and property boundary or public roadway.
- If boundary adjacent to water body, distance reduced by water width (maximum: 10 meters reduction).
- Setback distances comply with national requirements (e.g. TRGS 509).

M11: Tank Truck Loading Area - Traffic Control and Containment

- Loading/unloading on designated paved area connected to process drainage system.
- Traffic barriers or gates close access during operations.
- Wheel chocks (minimum 250mm height, non-sparking material) and parking brake applied.

- Signage: "NO ENTRY - LOADING OPERATION IN PROGRESS" and "FLAMMABLE LIQUID".
- Ground markings identify parking position and hose connection points.
- Dip-tube or bottom filling systems used to minimize splash and static electricity.
- Spill containment pad with drain; containment minimum 5-10 m^3.

M12: Railroad Tank Car Loading Area - Track Control and Protection

- Loading on designated track section isolated from main traffic.
- Blue flag protection, derail device, and lockout system on track switches.
- Track section connected to spill containment and process drainage.
- Tank car brakes applied and wheels chocked during operations.
- Remote-controlled shut-off valves at hose connections.

M13: Marine and Inland Vessel Bunkering Area - Port Authority Compliance

- Methanol bunkering only at locations designated and licensed by port authority.
- Coordination with vessel master, pilot, and port authority required before operations.
- Security perimeter minimum 25 meters radius during operations.

Note: More details in Baltic Ports Bunkering Guidebook in the Annex

M14: Marine Bunkering Operations - Safety Integration

- Vessel moored adequately to prevent movement.
- Connections pressure-tested before transfer (minimum 1.5× operating pressure).
- Communication protocol established (radio plus visual signals).
- Qualified personnel positioned at connection points: minimum two shore-side, two vessel-side.
- Operations suspended if: wind speed exceeds 10 m/s, wave height exceeds 1 meter, visibility less than 500 meters, or thunderstorm activity within 10 km.
- Ship/Shore Safety Checklist completed before transfer per ISGOTT or equivalent.

Note: More details in Baltic Ports Bunkering Guidebook in the Annex

2.2 Storage Tank Design and Construction

Scope: Tank specifications, materials, structural requirements, and protection systems

M15: Design Standard for Atmospheric Storage

- Methanol storage tanks designed to EN 14015 for atmospheric pressure operation (up to 0.17 bar).
- Design temperature range: -40°C to +93°C.
- Tank bottom uniformly supported on stable foundation per EN 14015.
- Design accounts for deadweight, liquid load, wind loads, seismic forces, and thermal expansion.

M16: Tank Construction Type

- Single-wall atmospheric tank construction acceptable.
- Permitted configurations: fixed cone roof, fixed dome roof, external floating roof, internal floating roof.
- Internal floating roof preferred: reduces vapor space 85-90%, prevents air/water entry.
- All fabrication and welding per EN 14015, or equivalent national standards.

M17: Tank Materials - Gaskets and Seals

- Gasket materials: PTFE (Teflon), Kalrez, or spiral wound with graphite filler.
- Materials prohibited: Buna-N/nitrile, natural rubber, butyl rubber, EPDM, neoprene, most Viton types.
- Hoses: PTFE inner liner; internal wire coil for electrical continuity; marked "METHANOL SERVICE"; replaced every 5 years minimum.
- Flame arresters: stainless steel construction only; aluminum prohibited.
- Pump seals: carbon-graphite or silicon carbide.

M18: Tank Foundation Design

- Tank bottom uniformly supported per EN 14015.
- Foundation options: compacted gravel/stone, concrete ringwall, reinforced concrete slab, or mat foundation.
- Foundation design accounts for deadweight, liquid load, seismic forces, wind loads, and soil settlement.
- Foundation surface shall be level, with a maximum deviation of <1 cm per meter radius, in accordance with EN 14015 and the project specification.
- Adequate drainage around tank perimeter.

M19: Tank Roof Design

- Fixed roof: welded cone or dome; minimum slope 1:12; all penetrations equipped with flame arresters.
- Internal floating roof: aluminum or steel pan; pontoon-supported or contact deck; dual rim seals; access hatches, gauge wells, automatic vents; anti-rotation guides; drain valves with check valves.

M20: Tank Venting and Pressure Relief

- Normal venting: pressure and vacuum relief valves per EN 14015; typical settings +2.5 to 10 mbar and -2.5 to -10 mbar.
- Flame arresters mandatory on all vent openings.
- Vent discharge minimum 4 meters above grade, directed away from traffic and personnel.
- Emergency venting: sized per EN 14015 for fire exposure.
- Nitrogen blanketing optional: high-purity nitrogen (<5 ppm oxygen).

M21: Tank Connections and Nozzles

- Primary connections:
  - Fill line: bottom or side entry with dip tube (submerged 2-3 meters)
  - Outlet line: bottom outlet with isolation valve outside containment
  - Vapor return: top connection (if vapor recovery used)
  - Drain: double block-and-bleed valve system
  - Sample connection: top or side with isolation valve
  - Instrumentation: level, temperature, pressure (minimum DN25)

    - Manway: minimum 600 mm diameter
- All primary containment connections shall be flanged in accordance with EN 1092-1, with a minimum pressure rating of PN16 (or higher where required by design pressure and temperature).
- Threaded connections prohibited on main tank nozzles; instrument connections ≤DN20 may be threaded if isolation valve installed.
- Bolts and fasteners: stainless steel or hot-dip galvanized.

M22: Corrosion Protection

- Carbon steel tanks: Impressed current or sacrificial anode cathodic protection shall be provided where required, designed, operated and monitored in accordance with EN 12954 (and EN 13636 for buried tanks or associated piping). Regular performance checks (e.g. at least annually) and potential measurements shall verify that protection criteria from EN 12954 are met.
- External carbon steel surfaces shall be protected by suitable coating systems designed and maintained in accordance with ISO 12944 , considering the relevant corrosivity category and expected durability.
- Stainless steel tanks: Cathodic protection is normally not required if appropriate stainless steel grades are selected for the environment and properly fabricated.
- Internal coatings for carbon steel: Where internal linings are used, inspection and renewal intervals shall follow the coating manufacturer's recommendations and the site's inspection programme (typically 5–7 years), with regular visual inspection for pitting and corrosion.

M23: Tank Inspection and Testing - New Construction

- Hydrostatic testing: fill with clean water to design level; hold minimum 24 hours; visual inspection for leaks, deformation, settlement; drain and dry before service.
- Weld testing: visual inspection per EN 14015; vacuum box testing on shell-to-bottom and roof-to-shell welds; radiographic, magnetic particle, or ultrasonic testing per standard requirements.
- Certification: test report issued by authorized Inspector or equivalent; all defects documented and repaired.

M24: Internal Floating Roof Specifications

- Deck: removable; aluminum or steel pan; pontoon or leg supports; minimal clearance to shell and fixed roof (300-600 mm).
- Rim seals: primary and secondary seals; methanol-compatible materials; maintains <1000 ppm concentration.
- Deck fittings: access hatches (minimum 600 mm diameter), sample lines with flexible hoses, drain valves with check valves, anti-rotation guides (minimum 2).
- Maintenance: inspection and seal replacement every 10-15 years or per manufacturer recommendation.

M25: Tank Nameplate and Identification

- Permanent nameplate per EN 14015: tank ID, construction date, design standard, design pressure and temperature, capacity, material specification, manufacturer, inspector name and date.
- Product identification: "METHANOL" in letters minimum 150 mm height on minimum 4 sides; GHS pictograms H225, H301, H311, H331,H370; "FLAMMABLE LIQUID – TOXIC – DAMAGES ORGANS" warning; emergency contact information.

M26: Thermal Expansion Allowance

- Methanol thermal expansion coefficient: 0.0012 /°C.
- Tank nominal capacity set at 85-90% of total volume.
- Freeboard minimum 10-15% for thermal expansion.
- Maximum fill limit 95% under any condition.
- Fill line temperature measurement with pre-alarm if exceeding design limit (typically 40-50°C).

M27: External Coating and Painting

- External steel surfaces shall be coated with light-coloured (e.g. white) or reflective aluminum/silver paint to reduce solar heat absorption. Protective paint systems shall be selected, applied and maintained in accordance with EN ISO 12944, considering the relevant corrosivity category (e.g. C3–C5) and required durability.
- For typical harbour environments, coating systems with at least medium to high durability (≈ 7–15 years or more) should be used; inspection and maintenance intervals shall follow the coating manufacturer's recommendations and the

site's inspection programme (often in the range of 5–10 years to first major repair).
- Internal surfaces of carbon steel tanks, where internal linings are applied, shall be inspected regularly and refurbished as required based on condition, service environment and manufacturer guidance (typically every 5–10 years).
- Floating roofs made of aluminium shall be protected against corrosion where necessary (e.g. at steel interfaces and fittings) and inspected regularly for coating damage and corrosion.

M28: Seismic and Wind Design

- Tank design accounts for site-specific seismic and wind loads per applicable codes.
- Seismic: site parameters from national maps (Eurocode 8); shell thickness verified per EN 14015; piping designed with flexibility; anchorage if analysis indicates uplift or sliding.
- Wind: speeds per local code (Eurocode 1 EN 1991); empty tank stability, shell buckling, roof uplift verified.
- Foundation design accounts for combined loads; settlement analysis performed.

M29: Static Electricity Control

- Fill rate limitations:
  - Maximum fill velocity 1 m/s until dip tube submerged
  - After submersion, maximum 7 m/s
  - Dip tubes terminate within 150 mm of tank bottom
- Grounding and bonding:
  - All conductive components bonded to common ground
  - Ground resistance maximum 10 ohms (preferably <1 ohm)
  - Bonding cables minimum 16 mm^2 copper
  - Connections verified before transfer operations
  - Truck grounding verified before loading
- Relaxation time: minimum 30 seconds after filling before sampling or gauging; 2-3 minutes if high-velocity filling or line contained different product.
- Design per EN IEC 60079-32-1.

Note: Methanol has low electrical conductivity; static electricity accumulation during filling is significant ignition risk.

M30: Product Quality Specifications

- Water content monitoring: maximum limits set according to application (e.g. marine fuel in line with ISO 6583:2024 grade selected; typical chemical feedstock values ≤0.1% by weight; other uses as defined in purchase specifications).
- Water content testing: Karl Fischer titration or an equivalent validated analytical method.
- Sampling frequency: after each receipt, at least weekly during storage, and before each delivery (or as required by contractual specifications and risk assessment).
- Quality parameters monitored as appropriate for the intended use, for example:
- Methanol purity (typically ≥99.85% for standard chemical grade methanol according to IMPCA or equivalent specifications).
- Water content.
- Inorganic chloride content (e.g. ≤0.5 mg/kg for marine fuel, per fuel-quality specification).
- Appearance (clear, colourless, free of suspended matter).
- Sampling from mid depth via a dedicated sampling connection, using clean, dry, sealed sample containers suitable for methanol service.
- Contamination prevention measures: nitrogen blanketing where feasible; internal floating roof or other vapour space minimisation to limit atmospheric contact; regular inspection for water accumulation; prompt draining and corrective action if free water is detected.

MX01: Existing Tanks: Assessment and Preparation

- Existing tanks converted to methanol service only after comprehensive assessment:
  - **Structural suitability:**
    - Tank construction per EN 14015 verified
    - No significant corrosion, structural damage, or foundation settlement
    - Design pressure/temperature adequate for methanol service (-40°C to +93°C)
  - **Previous service review:**
    - Tank history documented (products stored, repairs, incidents)
    - Tanks previously storing incompatible products (strong acids, oxidizers) generally excluded

- **Cleaning and decontamination:**
  - Tank drained, sludge/sediment removed
  - Interior washed until previous product undetectable (sampling required)
  - Tank entry per confined space procedures (per M80)
  - Visual inspection confirms cleanliness
- **Internal inspection before conversion:**
  - Tank bottom: ultrasonic thickness testing, 100% coverage preferred; minimum 3 mm retirement thickness
  - Shell and roof: visual inspection and Ultrasonic Testing (UT) at representative locations
  - Repairs completed before conversion approved

- Assessment documented; approved by facility management before proceeding with modifications.

MX02: Existing Tanks: Material Compatibility and Modification Requirements

- ALL materials contacting methanol verified compatible before conversion:
  - **Critical replacements required:**
    - Gaskets and seals: ALL replaced with PTFE, Kalrez, or spiral wound with graphite (per M17)
    - Roof seals (floating roof): replaced with methanol-compatible materials
    - Valve stem packing: graphite or compatible material
    - Internal coating (carbon steel tanks): existing coating removed if incompatible; new methanol-compatible coating applied
  - **Materials prohibited (must be replaced):**
    - Buna-N/nitrile, natural rubber, EPDM, neoprene, most Viton types
    - Aluminum components, galvanized steel
  - **Mandatory modifications:**
    - Flame arresters installed on ALL vent openings (per M20)
    - Dip tube or bottom fill system for static electricity control (per M29)
    - Grounding system verified: resistance ≤10 ohms; bonding connections accessible
  - **Instrumentation upgrades:**
    - High-high level alarm with overfill prevention (SIL 1 minimum) installed if not present (per M33)
    - Redundant level measurement if not present (per M31)
- Pressure testing after modifications: 1.5× design pressure for 4 hours minimum.
- Material certificates for all replacements maintained in facility records.

2.3 Safety Systems and Instrumentation

Scope: Control systems, monitoring, protective devices, alarms, and safety instrumentation

M31: Instrumentation and Control Philosophy

- Methanol storage tanks and associated systems equipped with instrumentation to ensure safe commissioning, operation, and maintenance.
- All critical measurements (level, pressure, temperature) provided with redundancy: minimum two independent measurement methods or sensors.
- All instrument readings displayed in control room or accessible to operators.
- Instrumentation maintained and calibrated per manufacturer recommendations; calibration records documented.

M32: Level Measurement and Monitoring

- Tank level measurement by minimum two independent methods:
  - Primary: radar, guided wave radar, or servo gauge
  - Secondary: float-type gauge, pressure transmitter, or ultrasonic
- Level transmitters provide continuous signal to control system.
- Local level indication (sight glass or gauge board) visible from tank access platform.
- Level measurement range: 0-100% of tank height with accuracy ±10 mm or ±0.5% of range.

M33: High-Level Alarm and Protection

- High-level alarm (HLA) set at 90% of tank capacity or as determined by thermal expansion calculation (per M26).
- High-high level alarm (HHLA) set at 95% of tank capacity.
- HHLA triggers automatic actions:
  - Stop incoming flow (close inlet valve or stop transfer pump)
  - Audible and visual alarm in control room and at loading area

    - Lockout of further filling until manually reset after level decreases
- Alarms based on independent level measurement from normal level indication.

M34: Overfill Prevention System

- Independent overfill prevention system with minimum SIL 1 (Safety Integrity Level 1) per IEC 61508/61511.
- System consists of:
    - Dedicated level switch or transmitter (separate from normal level measurement)
    - Logic solver (Programmable Logic Controller (PLC), relay, or dedicated safety controller)
    - Final element (automated valve closure or pump shutdown)
- Overfill prevention activates at 95% tank capacity; automatically stops all filling operations.
- System tested per SIL verification requirements (minimum annually for SIL 1).
- Manual reset required after activation; investigation and documentation of cause mandatory before restart.

M35: Pressure Measurement and Monitoring

- Tank vapor space pressure continuously monitored.
- Pressure transmitter range: -20 mbar to +20 mbar (or per tank design pressure/vacuum rating).
- Pressure reading displayed in control room.
- Pressure alarms:
    - High pressure alarm at 80% of relief valve set point
    - Low pressure alarm at 80% of vacuum relief valve set point

M36: Temperature Measurement

- Tank liquid temperature monitored:
    - Minimum one temperature sensor in tank (mid-level or per tank size: multiple sensors for tanks >5,000 m^3)
    - Temperature measurement on fill line (before tank inlet)
- Fill line temperature alarm if exceeding maximum design temperature or operational limit (typically 40-50°C).
- Temperature readings displayed in control room.

- Temperature measurement range: -50°C to +100°C with accuracy ±1°C.

M37: Pressure Relief Valve Monitoring

- Pressure relief valves (per M20) equipped with position indicators or acoustic monitors to detect discharge.
- Relief valve discharge detected and alarmed in control room.
- Alarm triggers investigation and documentation; continued discharge beyond set time (e.g., 5 minutes) triggers emergency response procedures.

M38: Pump Instrumentation and Protection

- Transfer pumps equipped with:
  - Discharge pressure transmitter
  - Motor current monitoring
  - Vibration monitoring (for pumps >50 kW or critical service)
  - Seal leak detection (for mechanically sealed pumps)
- Pump protection:
  - Low suction pressure shutdown (prevents cavitation)
  - High discharge pressure shutdown
  - Motor overload protection
  - High vibration alarm and shutdown
- Emergency shutdown capability from control room and local pump area.

M39: Emergency Shutdown System (ESD)

- Facility-wide emergency shutdown system installed.
- ESD system architecture:
  - Manual ESD activation from minimum two locations (control room and field location near tank/loading area)
  - Automatic ESD triggers: fire detection, gas detection (if installed per chapter 2.6), high-high level, extreme pressure deviation
  - ESD actions: close all automated isolation valves, stop all transfer pumps, activate alarms
- ESD valves: fail-safe close (spring return or fail-safe actuator); closure time maximum 30 seconds.
- ESD system tested quarterly; full functional test annually; documentation maintained.

M40: Control Room and Human-Machine Interface (HMI)

- Control room provides centralized monitoring and control of methanol storage and transfer operations.
- HMI displays:
  - Tank levels, pressures, temperatures (real-time trending)
  - Pump status and flow rates
  - Alarm summary and historical alarm log
  - Loading/unloading operation status
  - Emergency shutdown system status
- Alarm management per IEC 62682 or equivalent:
  - Alarms prioritized (critical, high, medium, low)
  - Alarm shelving and acknowledgment capability
  - Alarm rate monitoring (avoid alarm floods)
- Control room staffed during all loading/unloading operations or remote monitoring with rapid response capability.

M41: Uninterruptible Power Supply (UPS)

- Critical instrumentation and control systems powered by UPS.
- UPS capacity: minimum 30 minutes runtime for:
  - Level, pressure, temperature monitoring
  - Emergency shutdown system
  - Control room HMI and communication systems
  - Emergency lighting and alarm systems
- UPS battery tested monthly; load test annually; batteries replaced per manufacturer recommendations.

M42: Communication Systems

- Facility equipped with reliable communication systems:
  - Two-way radio system covering entire facility (handheld radios for operators, fixed radios in control room)
  - Telephone/intercom system (control room to loading areas, pump stations, tank areas)
  - Public address (PA) system for emergency announcements
  - Emergency notification system (automatic call-out to fire department, management, emergency responders)

- Communication systems tested monthly; backup power provided (UPS or batteries).

M43: Instrumentation Failure and Failsafe Design

- Instrumentation designed with failsafe philosophy:
  - Level transmitter failure: activate high-level alarm
  - Pressure transmitter failure: activate alarm
  - Flow transmitter failure: stop loading operation
  - Control valve actuator failure: valve moves to safe position (typically closed for inlet valves)
- Critical instruments provide fault detection and self-diagnostics.
- Instrument failure generates alarm in control room; operators verify system status and take appropriate action.

M44: Calibration and Maintenance Program

- All safety instrumentation calibrated per written schedule:
  - Level transmitters: annually minimum
  - Pressure transmitters: annually minimum
  - Temperature sensors: biennially minimum
  - Flow meters: annually minimum
  - Safety instrumented systems (SIL-rated): per SIL verification calculation (typically 6-12 months)
- Calibration performed by qualified technicians using traceable standards.
- Calibration certificates and records maintained minimum 10 years.
- Preventive maintenance performed per manufacturer recommendations; documentation maintained.

M45: Documentation and As-Built Drawings

- Complete instrumentation documentation maintained:
  - Instrument datasheets and specifications
  - Instrument location drawings (plan and elevation)
  - Piping and instrumentation diagrams (P&IDs) showing all instruments, control valves, interlocks
  - Control system logic diagrams (ladder logic, function block diagrams)

    - Safety instrumented system (SIS) documentation: SIL calculations, proof test procedures
    - Cause and effect matrices (alarms and shutdowns)
- As-built drawings updated after modifications; change management process enforced.
- Documentation accessible to operators, maintenance personnel, and emergency responders.

2.4 Product Handling and Transfer Systems

Scope: Piping, loading/unloading equipment, material compatibility, and transfer operations

M46: Piping Design Standards

- All methanol piping shall be designed, constructed, inspected and tested in accordance with EN 13480 (Metallic industrial piping) and applicable pressure equipment regulations.
- Design pressure: minimum 10 bar or 1.5 × maximum operating pressure, whichever is greater.
- Design temperature range: −50 °C to +100 °C (or per site-specific requirements).
- Piping supports shall be designed to accommodate thermal expansion, vibration and external loads, in line with EN 13480 design rules.
- Stress analysis shall be performed for critical piping systems (e.g. high pressure, large diameter, elevated temperature, complex routing, or where required by EN 13480 / project specifications).

M47: Piping Materials

- Carbon steel: EN 10216 or equivalent; suitable for ambient temperature methanol service.
- Stainless steel: Types 304L or 316L (316L preferred for coastal environments).
- Piping material selection consistent with connected equipment (tanks, pumps, valves).
- Materials prohibited: aluminum alloys, galvanized steel, copper, zinc, lead alloys.
- External coating for corrosion protection: epoxy, polyurethane, or equivalent; underground piping with cathodic protection per EN 12954.

M48: Valve Selection and Specification

- All valves in methanol service selected for compatibility:
  - Body material: carbon steel or stainless steel (316L preferred)
  - Trim material: stainless steel
  - Seats: PTFE (preferred), Kalrez, or metal-to-metal
- Isolation valves: ball valves or gate valves; minimum Class 150 (PN16).
- Control valves: globe valves or ball valves with pneumatic or electric actuators; fail-safe position defined (typically fail-closed for inlet lines).
- Check valves: swing check or spring-loaded check valves on pump discharge and fill lines.
- Emergency shutdown (ESD) valves: automated actuated valves (pneumatic or electric); fail-safe closed; closure time maximum 30 seconds.
- Valve stem seals: bellows-sealed or packed with graphite packing.

M49: Gaskets and Sealing Materials

- Gasket materials compatible with methanol: PTFE (Teflon), spiral wound with graphite filler, Kammprofile with graphite, or Kalrez.
- Flange gaskets: full-face or ring-type per flange standard; gasket rating matched to flange class.
- Threaded connections: PTFE tape compatible with methanol; threaded connections limited to instrument connections ≤DN20.

M50: Hoses and Flexible Connections

- Hoses for methanol service: PTFE inner liner; wire-reinforced for pressure rating and electrical continuity.
- Hose identification: clearly marked "METHANOL SERVICE" with date of manufacture and maximum working pressure.
- Hose pressure rating: minimum 10 bar or 4×maximum operating pressure, whichever is greater.
- Hose end fittings: stainless steel; crimped or reusable fittings per manufacturer specification.
- Hose inspection: visual inspection before each use; pressure test annually; replacement every 5 years maximum or per manufacturer recommendation.
- Hose storage: protected from sunlight, ozone, and mechanical damage; hung or stored on racks (not coiled on ground).

M51: Loading Arms (Truck and Railcar)

- Loading arms: fixed rigid pipe construction or articulated swing-arm design.
- Loading arm materials: stainless steel preferred; carbon steel acceptable with appropriate coatings.
- Loading arm features:
  - Dry-break coupling at arm end (prevents spillage during connection/disconnection)
  - Integrated vapor return connection (if vapor recovery system used)
  - Emergency breakaway coupling: activates if vehicle moves unexpectedly; closes both sides automatically; maximum spillage 1 liter
  - Position interlocks: loading permitted only when arm in safe operating envelope
- Bottom loading preferred: dip tube extends to tank bottom; minimizes splash and static electricity.
- Top loading (if unavoidable): splash-filling prohibited; use dip tube or fill pipe extending below liquid surface.

M52: Marine Loading Arms

- Marine loading arms: articulated arms with 3 or 4 swivel joints; designed for ship/barge motion (tide, waves, current).
- Loading arm materials: stainless steel preferred for marine environment.
- Loading arm design: balance system (counterweights or hydraulic) to allow operator movement with minimal force.
- Emergency release coupling (ERC): mechanical or hydraulic release if ship drifts beyond safe distance; coupling separates and both sides close automatically; maximum spillage 5 liters.
- Loading arm envelope: clearly defined operating limits (horizontal, vertical, rotation); position monitoring with alarms and interlocks.
- Vapor return arm: separate arm for vapor recovery during loading (if required).
- Marine loading arms tested per OCIMF (Oil Companies International Marine Forum) guidelines or equivalent.

Note: See more details on safe bunkering operations in Baltic Ports Bunkering Guidebook in the Annex

M53: Pumps - Selection and Design

- Methanol transfer pumps: centrifugal pumps (most common) or positive displacement pumps (for precise flow control or high pressure).
- Pump materials:
  - Casing: stainless steel 316L preferred (304L acceptable); carbon steel with appropriate coatings for non-critical applications
  - Impeller: stainless steel 316L or 304L.
  - Shaft: stainless steel.
- Pump seals:
  - Mechanical seals with carbon-graphite or silicon carbide faces; seal design and installation in accordance with EN 12756 (or equivalent), with suitable flush, buffer or barrier fluid systems specified by the seal manufacturer to minimise leakage and emissions.
  - Magnetic drive (seal-less) pumps: preferred for leak-free operation; no dynamic seals.
- Pump capacity: sized for maximum required flow rate plus 10–20% margin; multiple pumps provided for redundancy where required.
- Pump discharge pressure: sufficient to overcome static head, friction losses, and downstream equipment pressure drop.

M54: Pump Installation and Protection

- Pumps installed on concrete foundations with vibration isolation (where required).
- Suction piping: short, straight run; minimum elbows; eccentric reducer (flat side up) at pump suction to avoid air pockets.
- Pump suction strainer: Y-type or basket strainer (20-40 mesh); differential pressure indicator; cleaned regularly.
- Pump discharge: check valve and isolation valve immediately after pump discharge.
- Pump protection (integrated with instrumentation per chapter 2.3):
  - Low suction pressure shutdown
  - High discharge pressure shutdown
  - Motor overload protection
  - High vibration alarm/shutdown (for critical pumps)
  - Seal leak detection (drain to safe location; alarm on leakage)
- Emergency shutdown: local pushbutton at pump and remote from control room.

M55: Static Electricity Control in Transfer Operations

- Critical: Methanol has low electrical conductivity; static electricity generation during transfer operations is significant ignition hazard.
- Grounding and bonding:
  - All transfer equipment bonded: tanks, pumps, piping, loading arms, hoses, trucks, railcars
  - Bonding cables: minimum 16 mm^2 copper; connections cleaned and verified before operations
  - Ground resistance: maximum 10 ohms (preferably <1 ohm); measured and documented
- Truck/railcar grounding verification system:
  - Automatic grounding verification before loading permitted
  - Grounding clamp attached to designated grounding point on vehicle
  - Resistance continuously monitored; loading stopped if resistance exceeds 10 ohms
  - Visual indication (green light) confirms proper grounding
  - System tested monthly
- Fill rate control:
  - Initial fill rate maximum 1 m/s velocity until outlet submerged (minimum 0.3 meters submergence)
  - After submersion, velocity increased to maximum 7 m/s
  - Flow rate monitored; automatic shutdown if exceeding safe velocity
  - Bottom loading preferred to minimize splash
- Relaxation time:
  - Minimum 30 seconds after filling stops before opening hatches, sampling, or gauging
  - Minimum 2-3 minutes if high-velocity filling, line switching, or different product previously in line
- Design per EN IEC 60079-32-1 or equivalent.

M56: Loading/Unloading Instrumentation

- Loading arms equipped with:
  - Flow measurement: mass or volumetric flow meter; accuracy ±0.5% of reading
  - Pressure transmitter on loading line
  - Emergency shutdown valves (actuated, fail-safe close)
- Loading operations monitoring:

  - Total volume loaded/unloaded displayed and recorded
  - Flow rate monitored and alarmed if exceeding maximum safe rate (per M55)
  - Automatic shutdown on high flow rate or low pressure (hose rupture detection)
- Preset batch controller for truck loading:
  - Operator enters desired quantity
  - Loading stops automatically at preset volume
  - High-high cutoff (typically +2% of preset) as backup
- Loading totalizer: cumulative volume totals for daily/monthly reconciliation; tamper-proof.

M57: Vapor Recovery System (if applicable)

- Vapor recovery during loading operations: vapors displaced from truck/railcar/ship returned to storage tank or vapor treatment system.
- Vapor return line: sized for maximum vapor displacement rate; minimum DN50 for truck loading, DN100 for ship loading.
- Vapor return connection: dry-break coupling on loading arm; connected before liquid transfer begins.
- Vapor line flame arrester: stainless steel construction; installed on vapor return line before tank; protects tank from external ignition source.
- Vapor balance system: tank vapor space pressure maintained within acceptable range during loading; pressure relief valve on vapor line if required.
- Vapor recovery not required for atmospheric tanks with adequate venting; however, recommended for environmental and safety reasons (reduces emissions and vapor cloud formation).

M58: Leak Detection for Transfer Lines

- Transfer lines equipped with leak detection where practical:
  - Buried piping: leak detection wire, fiber optic sensing, or secondary containment with monitoring
  - Above-ground piping in sensitive areas: visual inspection, drip pans with leak detection, or gas detection
- Leak detection methods:
  - Mass balance: compare flow out vs. flow in; alarm on discrepancy >2%
  - Pressure monitoring: monitor line pressure during static periods; alarm on pressure drop

  - Acoustic leak detection: sensors detect sound of escaping liquid
  - Visual inspection: regular inspection of above-ground piping (daily during operations)
- Leak detection alarm: triggers in control room; automatic isolation of affected section if confirmed leak.

M59: Pipeline Segmentation and Isolation

- Long transfer pipelines (>500 meters) segmented with isolation valves: maximum segment length 500-1000 meters.
- Isolation valves: remotely operated (motorized or pneumatic) or manual valves at strategic locations (site boundaries, before/after pumps, at elevation changes).
- Isolation valve locations:
  - Entry/exit points of facility boundaries
  - Before and after major equipment (pumps, loading racks)
  - High points (to facilitate draining and air removal)
- Pipeline drainage: low-point drains with double block-and-bleed valves; drain to safe location (containment or treatment system).

M60: Thermal Relief Protection

- Piping sections that can be isolated (blocked-in) while full of liquid equipped with thermal relief valves (TRVs).
- TRV application: between isolation valves where thermal expansion could cause over-pressure (e.g., pipe exposed to sunlight, pipe sections between block valves).
- TRV sizing: per EN 13480; adequate capacity for thermal expansion scenario.
- TRV discharge: to safe location (atmosphere at safe height, containment, or vapor recovery system); not to confined space.

M61: Expansion Joints and Flexibility

- Piping systems designed with flexibility to accommodate:
  - Thermal expansion/contraction
  - Tank settlement
  - Equipment vibration
  - Seismic movement
- Flexibility provided by:

  - Expansion loops (L-bends, Z-bends)
  - Metallic expansion joints (bellows-type; only where loops not feasible)
  - Flexible hoses at equipment connections (pumps, loading arms)
- Expansion joints: stainless steel bellows; tie rods to limit movement; designed per EN 14917.
- Expansion joints inspected annually; replaced per manufacturer recommendation or if signs of fatigue/damage.

M62: Piping Identification and Marking

- All methanol piping clearly identified:
  - Color coding: per ISO 14726 (yellow YE for flammable liquids) or local standard.
  - Labeling: "METHANOL" with directional flow arrows at regular intervals (maximum 10 meters) and at all valves, connections, and wall penetrations
  - Hazard markings: GHS pictograms (H225, H301, H311, H331, H370) at strategic locations
- Valve identification: each valve tagged with unique number; valve position labeled (open/closed).
- Underground piping: marker posts at changes of direction, valves, and regular intervals (maximum 50 meters).

M63: Pressure Testing and Commissioning

- All new or modified piping pressure tested before commissioning:
  - Hydrostatic test: 1.5× design pressure for minimum 4 hours; water or other compatible test fluid
  - Pneumatic test (if hydrostatic not feasible): 1.1× design pressure with inert gas (nitrogen); incremental pressurization; additional safety precautions (personnel exclusion zone)
- Leak test: visual inspection during pressure test; no leakage permitted at flanges, valves, welds.
- Flushing: piping flushed with water or methanol before commissioning to remove construction debris, mill scale, welding slag.
- Documentation: pressure test certificate issued by qualified inspector; test charts, procedures, and results maintained.

M64: Above-Ground Piping Installation

- Above-ground piping shall be installed on pipe racks, pipe bridges, or sleepers.
- Pipe supports shall be spaced and designed in accordance with EN 13480 and the project piping design specification, considering pipe weight (empty, operating, test), insulation, and external loads (e.g. wind, snow, thermal expansion).
- Pipe support materials: carbon or stainless steel with appropriate corrosion protection; where piping is insulated, suitable design measures (e.g. saddles, pads, or non-absorbent inserts) shall be used at support contact points to minimise Corrosion under insulation (CUI).
- Piping clearances: minimum 0.5 m from walkways, structures and other equipment; minimum 2.0 m above grade at pedestrian crossings (or in accordance with site-specific safety requirements and applicable regulations).
- Piping slope: minimum 1:100 towards low points and drain points to allow complete drainage and avoidance of trapped liquid.

M65: Underground Piping Installation

- Underground piping: externally coated and wrapped for corrosion protection; cathodic protection system installed per EN 12954.
- Burial depth: minimum 0.8 meters below grade (or below frost line in cold climates); minimum 1.2 meters under roads or traffic areas.
- Bedding: piping laid on compacted sand or fine gravel bed (minimum 150 mm); backfilled with sand or fine material (no rocks); compacted in layers.
- Warning tape: buried 0.3 meters above piping; marked "CAUTION - METHANOL PIPELINE BURIED BELOW".
- Marker posts: installed at pipeline route changes, valves, and regular intervals; marked with "METHANOL PIPELINE" and emergency contact information.
- As-built drawings: precise location and depth of underground piping documented; drawings accessible for future excavation or maintenance.

M66: Spill Containment for Transfer Areas

- All transfer areas (loading racks, pump stations) equipped with spill containment:
  - Concrete pads with raised edges or curbs (minimum 100 mm height)
  - Floor sloped toward collection sump

    - Containment capacity: minimum volume of largest single hose or loading arm capacity plus 10%
- Sump with leak detection and level alarm; sump pumped to treatment system or containment (per M8).
- Drip pans under pumps, valves, flanges where leaks possible; drip pans drained regularly.

M67: Winterization and Freeze Protection

- Piping and equipment exposed to freezing temperatures protected:
    - Insulation: thermal insulation on piping; thickness per heat loss calculation
    - Heat tracing: electric or steam heat tracing where required to maintain minimum temperature (typically +5°C minimum)
    - Drainage: piping designed for complete drainage; drain valves at low points; draining procedures documented
- Heat tracing controlled by thermostats; temperature monitored and alarmed.
- Winterization checklist: prepared and executed before winter season; includes testing of heat tracing, insulation inspection, verification of drainage procedures.

M68: Maintenance Access and Safety

- Piping and equipment arranged to allow safe maintenance access:
    - Valves accessible from grade or platforms (maximum 2 meters height without platform)
    - Flanges accessible for bolt removal and gasket replacement
    - Instruments accessible for calibration and maintenance
- Platforms, ladders, stairs per EN ISO 14122 standards: guardrails, toe boards, non-slip surfaces.
- Isolation and lockout points: clearly identified; sufficient space for isolation procedures and lockout/tagout devices.

2.5 Operational Procedures and Controls

Scope: Operating procedures, training, process control and quality management

M69: Operational Procedures Documentation

- Written procedures maintained for all phases of operation:
  - Commissioning and decommissioning (tanks, piping, equipment)
  - Normal operations (filling, storage, transfer, loading/unloading)
  - Abnormal situations and emergency response
  - Maintenance during production
  - Inspection and testing activities
- Procedures address temporary safety measures during maintenance or modifications.
- Procedures accessible to all relevant personnel; updated after incidents or process changes.
- Change management process ensures procedures updated before implementing operational changes.

M70: Commissioning Procedures

- Before commissioning, facility preparation:
  - Tanks and piping cleaned and dewatered
  - Leak testing with nitrogen or air (per design pressure requirements)
  - Flushing with nitrogen until oxygen content <0.5%
  - Visual inspection for construction debris, tools, foreign objects
- Initial filling with methanol conducted at controlled rate; monitoring for leaks, pressure, temperature.
- Water content verified within specification (per M77) before tank placed in service.
- Commissioning witnessed and approved by qualified personnel; commissioning report documented.

M71: Decommissioning Procedures

- Tank or system decommissioning:
  - Empty to maximum extent possible
  - Residual methanol removed by draining and/or evaporation
  - Flushing with nitrogen until methanol concentration <100 ppm
  - Flushing with air until oxygen content >19% (if entry required)
  - Gas testing before any hot work or confined space entry
- All liquid methanol and contaminated flushing fluids sent to treatment or disposal per environmental regulations.
- Decommissioning documented; vessel tagged "OUT OF SERVICE" until recommissioned.

M72: Control of Storage Conditions

- Tank liquid level, temperature, and pressure continuously monitored (per chapter 2.3).
- Operator response to abnormal conditions:
  - Level approaching high alarm: reduce or stop filling; investigate cause
  - Temperature exceeding normal range: investigate source (ambient heating, product temperature); implement cooling if necessary
  - Pressure deviation: verify venting system operation; check for blockage or malfunction
- Monitoring system settings allow intervention before safety systems (alarms, shutdowns) activate.
- Operating limits documented in facility operating manual; deviations recorded and investigated.

M73: Tank Filling Operations

- Tank filling conducted per written procedure addressing:
  - Verification of available tank capacity before starting transfer
  - Confirmation of correct product (methanol grade, specification)
  - Grounding and bonding verification (per M29)
  - Fill rate control (per M29 static electricity limits)
  - Continuous monitoring of level, pressure, flow rate
  - Operator presence during filling operations

- Filling stopped immediately if abnormal conditions detected (high level alarm, pressure deviation, leak indication).
- Filling operations logged: date, time, quantity, source, operator name.

M74: Tank Discharge Operations

- Tank discharge (unloading) conducted per written procedure:
  - Verification of receiving vessel/truck capacity
  - Grounding and bonding verification
  - Valve lineup verification before starting transfer
  - Flow rate monitoring
  - Prevention of tank low-level conditions (maintain minimum liquid level to prevent pump cavitation or vapor entrainment)
- Discharge operations logged: date, time, quantity, destination, operator name.

M75: Loading and Unloading - General Requirements

- Loading/unloading operations conducted only when written procedures available and followed.
- Pre-operation checklist completed before each operation:
  - Correct truck/railcar/vessel positioned and secured
  - Grounding verified (per M29)
  - Emergency equipment accessible (fire extinguisher, spill kit, PPE)
  - Communication established between operator and driver/vessel personnel
  - Weather conditions acceptable (no thunderstorms, extreme wind)
- Loading/unloading area access restricted; physical barriers in place; signage posted.

M76: Product Quality Verification (Operational)

- Methanol quality verified before acceptance into storage:
  - Water content: maximum per application specification (marine fuel <0.5%; chemical feedstock <0.1%)
  - Visual inspection: clear, free of suspended matter or contamination
  - Temperature: within acceptable range for storage tank
  - Odor: characteristic methanol odor (detection of off-odors indicates contamination)

- Sampling:
  - Samples collected from mid-depth of tank or from transfer line
  - Sample containers clean, dry, glass or PTFE-lined
  - Chain of custody maintained for laboratory samples
- Testing frequency:
  - Upon each receipt (before acceptance into storage)
  - Weekly during storage (for long-term storage)
  - Before each delivery (to verify specification compliance)
- Laboratory analysis: Karl Fischer titration for water content; additional testing per customer specification.
- Out-of-specification product segregated; disposition determined (blending, treatment, or return to supplier).

M77: Water Content Management

- Methanol water content maintained within specification limits.
- Water contamination sources minimized:
  - Nitrogen blanketing (if used) prevents atmospheric moisture ingress
  - Internal floating roof (if installed) minimizes vapor space and condensation
  - Tank venting equipped with desiccant breathers (optional; for critical applications)
- Water accumulation in tank bottom monitored:
  - Regular inspection for water layer (water settles below methanol)
  - Water drainage if detected (per environmental controls)
  - Investigation of water source (condensation, leaking roof, contaminated receipt)
- Water content adjustment: if methanol too dry, controlled water addition per specification; if too wet, blending with drier product or treatment.

M78: Contamination Prevention

- Measures to prevent methanol contamination:
  - Dedicated storage tanks (methanol only; no product switching)
  - Dedicated piping and transfer equipment (or thorough flushing if shared)
  - Clean filling procedures (no introduction of dirt, rust, or foreign matter)
  - Proper tank maintenance (internal coating integrity, roof seals)
- If contamination detected:
  - Product segregated and analyzed

- Source of contamination identified and corrected
- Tank cleaned if necessary before return to service

M79: Operator Training and Competency

- All personnel involved in methanol operations trained on:
  - Methanol hazards (flammability, toxicity, invisible flame)
  - Safe handling procedures (filling, transfer, loading, unloading)
  - Emergency response (spill response, fire, exposure, evacuation)
  - Personal protective equipment use (gloves, face shields, emergency breathing apparatus)
  - Static electricity hazards and control measures
  - Environmental protection (spill prevention, wastewater management)
- Training program includes:
  - Initial training before assignment to methanol operations
  - Refresher training annually minimum
  - Competency assessment (written test, practical demonstration)
  - Documentation of training completion
- Operators qualified and authorized before performing critical operations (tank filling, loading trucks, emergency response).

M80: Permit-to-Work System

- Permit-to-work system implemented for non-routine activities:
  - Hot work (welding, cutting, grinding) in or near methanol areas
  - Confined space entry (tanks, vessels, pits)
  - Line breaking (opening flanges, disconnecting hoses)
  - Excavation near underground piping
  - Maintenance on pressurized systems
- Permit requirements:
  - Hazard identification and risk assessment
  - Isolation and energy control (lockout/tagout)
  - Gas testing (before and during work)
  - PPE requirements specified
  - Emergency response provisions
  - Authorized signatures (supervisor, safety officer, operator)
- Permit valid for specified duration (typically one shift or one day); renewed if work extends beyond period.

- Permits reviewed and closed after work completion; lessons learned documented if incidents occur.

M81: Lockout/Tagout Procedures

- Energy isolation (lockout/tagout) procedures for maintenance and repair:
  - Equipment de-energized and isolated (electrical, mechanical, hydraulic, pneumatic, gravity)
  - Isolation points locked with personal locks (one lock per worker)
  - Tags identify reason for lockout, date, and responsible person
  - Verification of zero energy state before work begins
- Methanol-specific considerations:
  - Piping and equipment drained and depressurized before opening
  - Residual methanol flushed with nitrogen or water (depending on work type)
  - Gas testing confirms methanol concentration <0.6% before entry or hot work
- Only authorized person who applied lock may remove it; exceptions require formal management-of-change procedure.

M82: Hot Work Controls

- Hot work in methanol areas strictly controlled:
  - Hot work permit required (per M80)
  - Area cleared of methanol vapors (gas testing confirms <0.6%)
  - Fire watch posted with extinguisher and communication to emergency services
  - Continuous gas monitoring during hot work (work stopped if methanol detected)
- Minimum 15-meter exclusion zone around hot work; methanol transfer operations stopped in adjacent areas.
- Post-work fire watch: area monitored for minimum 30 minutes after hot work completion.

M83: Personal Protective Equipment (PPE)

- Minimum PPE for methanol operations:
  - Safety glasses or face shield (splash protection)

  - Chemical-resistant gloves (nitrile or neoprene for incidental contact; butyl rubber for immersion)
  - Safety footwear (chemical-resistant where spillage possible)
  - Flame-resistant clothing (where fire risk present)
- Additional PPE for specific tasks:
  - Full face shield for connecting/disconnecting hoses or opening flanges
  - Chemical-resistant apron or suit for tank cleaning or spill cleanup
  - Self-contained breathing apparatus (SCBA) or supplied-air respirator for emergency response or confined space entry
- Emergency escape masks (air-purifying respirator with organic vapor cartridge, e.g. EN 14387 type AX) available at strategic locations; minimum one per two workers.
- PPE inspection before use; damaged PPE removed from service and replaced.

M84: Housekeeping and Facility Maintenance

- Good housekeeping practices maintained:
  - Tank farm and loading areas kept clean and free of debris, spilled product, or accumulated waste
  - Drains kept clear and functional
  - Access routes and emergency exits unobstructed
  - Signage legible and properly positioned
  - Lighting adequate for day and night operations
- Preventive maintenance program:
  - Equipment inspected and maintained per manufacturer recommendations and facility schedules
  - Deficiencies corrected promptly; equipment tagged "OUT OF SERVICE" until repaired
  - Maintenance records documented (date, work performed, parts replaced, technician name)
- Grounds maintenance: vegetation controlled around tanks and piping to allow inspection and emergency access; drainage ditches kept clear.

M85: Management of Change (MOC)

- Formal management-of-change process for facility modifications:
  - Hardware changes (new equipment, piping modifications, instrument replacements)
  - Procedural changes (operating procedures, maintenance practices)

  - Organizational changes (staffing, responsibilities, contractor use)
  - Temporary modifications (bypasses, temporary piping, out-of-service equipment)
- MOC process includes:
  - Description of proposed change and justification
  - Hazard identification and risk assessment
  - Review of safety, environmental, and operational impacts
  - Update of drawings, procedures, and training materials
  - Authorization by facility management before implementation
  - Post-implementation review to verify change successful
- Emergency changes: temporary approval permitted for safety-critical repairs; formal MOC completed within 48 hours.

M86: Incident Reporting and Investigation

- All incidents involving methanol reported and investigated:
  - Spills (any quantity released to environment)
  - Fires or vapor releases
  - Equipment failures (pump failures, valve leaks, instrument malfunctions)
  - Injury or exposure incidents
  - Near-misses (incidents that could have caused harm but did not)
- Incident investigation:
  - Immediate response and containment
  - Root cause analysis (what happened, why it happened, how to prevent recurrence)
  - Corrective actions identified and implemented
  - Investigation report documented within 30 days
  - Lessons learned communicated to all personnel
- Trends analysis: periodic review of incidents to identify systemic issues or recurring problems.

M87: Operational Record Keeping

- Operational records maintained:
  - Daily operating logs (tank levels, transfers, incidents, operator notes)
  - Loading/unloading records (quantity, date, time, truck/vessel identification)
  - Quality control data (water content, laboratory results)
  - Maintenance and inspection records (per chapter 2.7)

  - Training records (per M79)
  - Permit-to-work records (per M80)
  - Incident reports (per M86)
- Records retention: minimum 5 years for operational records; 10 years for safety-critical records (inspections, incidents, modifications); indefinitely for as-built drawings and design documents.
- Records accessible to regulatory authorities, insurance inspectors, and facility management.

M88: Communication and Coordination

- Effective communication maintained:
  - Shift handovers: outgoing and incoming operators review status, ongoing activities, abnormal conditions
  - Management briefings: regular (weekly/monthly) meetings on safety performance, incidents, planned work
  - Contractor coordination: contractors briefed on facility hazards, procedures, emergency response before starting work
  - Emergency services coordination: fire department and emergency responders familiar with facility layout, hazards, and emergency contacts
- Communication systems tested regularly (radios, phones, alarms); backup systems available.

M89: Grounding and Bonding Verification (Operational)

- Grounding verification performed before each truck/railcar loading operation:
  - Grounding clamp attached to designated grounding point on vehicle
  - Grounding monitor confirms resistance <10 ohms
  - Green light or visual confirmation indicates proper grounding
  - Loading interlock prevents operation if grounding not verified
- Hoses and loading arms bonded to facility grounding system; bonding continuity verified annually (per chapter 2.7).
- Static electricity incidents investigated to identify and correct grounding failures.

MX03: Existing Tanks: Commissioning of Converted Tanks

- Converted tanks commissioned per specific procedure before methanol introduction:
  - **Pre-commissioning verification:**

        - All modifications completed and pressure tested
        - Material replacements documented with certificates
        - Instrumentation calibrated and safety systems functionally tested
        - Personnel trained on methanol-specific hazards (per M79)
    - **Initial methanol fill:**
        - Nitrogen purging: tank purged until oxygen content <0.5%
        - Controlled fill rate: maximum 1 m/s velocity until dip tube submerged
        - Continuous monitoring: level, pressure, temperature, leak detection
        - Water content verification after fill: per specification (typically <0.5% for marine fuel)
    - **Enhanced monitoring period:**
        - First 30 days: daily visual inspection for leaks, coating condition (via manway if accessible)
        - First 6 months: monthly external inspection instead of annual
        - First year: coating condition assessment at 6 months and 12 months
    - **Documentation:**
        - Commissioning completion certificate issued
        - As-built drawings updated showing all modifications
        - Regulatory notification (if required by local authority)
- Conversion documented; tanks with conversion issues identified early and corrective actions implemented.

2.6 Detection and Monitoring Systems

Scope: Gas detection, leak detection, environmental monitoring, and alarm systems

M90: Gas Detection System - General Requirements

- Methanol vapor detection system installed at all locations where methanol vapor accumulation possible:
  - Loading/unloading areas (truck, rail, marine)
  - Pump stations and transfer equipment areas
  - Tank dike areas (if not fully open-air)
  - Confined spaces and below-grade areas within 15 meters of methanol operations
  - Indoor areas where methanol stored or handled
- Detection system provides:
  - Continuous monitoring (24/7 operation)
  - Alarms at two levels: low-level warning and high-level action
  - Visual and audible alarms in control room and local area
  - Integration with control systems for automatic actions (per chapter 2.3)

M91: Gas Detection - Detector Specifications

- Methanol vapor detectors: electrochemical or catalytic bead type; suitable for methanol detection in flammable range.
- Detector placement:
  - Low-level locations (methanol vapor slightly heavier than air; accumulates in low areas)
  - Breathing zone height (1.5 meters) at operator work locations
  - Near potential leak sources (pumps, valves, hose connections, loading arms)
- Detector coverage: number and positioning determined by scenario analysis considering:
  - Wind direction and ventilation patterns
  - Potential leak rates and locations

    - Response time requirements
- Detector specifications:
    - Detection range: 0-100% LEL (Lower Explosive Limit)
    - Accuracy: ±5% of reading
    - Response time: <30 seconds (T90)

M92: Gas Detection - Alarm Levels and Actions

- Alarm setpoints:
    - Low alarm (warning): 0.6-1.2%; alerts operators to investigate
    - High alarm (action): 1.5-1.8%; triggers automatic actions:
        - Stop loading/unloading operations
        - Close ESD valves (if configured)
        - Activate visual/audible alarms
        - Notify emergency responders (if configured)
- Operators respond to alarms:
    - Investigate source of vapor release
    - Implement corrective actions (stop transfer, close valves, isolate equipment)
    - Evacuate personnel from affected area if necessary
    - Reset alarm only after vapor concentration returns to safe levels and source corrected

M93: Gas Detection - Calibration and Testing

- Gas detectors calibrated regularly:
    - Bump test (functionality check with test gas): weekly minimum
    - Full calibration: monthly minimum or per manufacturer recommendation
    - Calibration gas: certified methanol/air mixture at known concentration
- Detector maintenance:
    - Sensors replaced per manufacturer life expectancy (typically 2-3 years for electrochemical; 5 years for catalytic)
    - Visual inspection for physical damage, contamination, or obstruction
    - Malfunction investigated and corrected immediately; detector replaced if defective
- Calibration and maintenance records documented; accessible for audits.

M94: Fire Detection System

- Fire detection system installed in areas where methanol fire risk present:
  - Loading/unloading areas
  - Pump stations and enclosed equipment areas
  - Control rooms and electrical rooms (adjacent to methanol areas)
- Fire detector types:
  - Flame detectors (UV/IR or multi-spectrum): detect methanol's invisible flame
  - Heat detectors: backup for flame detection
  - Smoke detectors: not reliable for methanol fires (clean-burning); used only in occupied buildings
- Fire detection system connected to:
  - Fire alarm panel with audible/visual alarms
  - Automatic fire suppression systems (if installed per chapter 2.8)
  - Emergency notification to fire department

M95: Leak Detection - Liquid Methanol

- Liquid methanol leak detection where practical:
  - Drip pans or collection sumps under pumps, valves, flanges with level switches or visual inspection
  - Mass balance monitoring: compare flow in vs. flow out; alarm on discrepancy >2%
  - Visual inspection: regular operator rounds (per M84) to identify leaks early
- Leak detection in secondary containment (dikes):
  - Level monitoring in collection sumps (per M8, M9)
  - Alarm on liquid accumulation indicates leak from primary containment

M96: Environmental Monitoring

- Wastewater monitoring (per M8):
  - Methanol concentration in process wastewater before discharge
  - pH monitoring to verify neutralization
  - Discharge flow rate monitoring and totalization
- Stormwater monitoring:
  - Visual inspection before discharge from clean water drains
  - pH and methanol spot-testing if contamination suspected
  - Automatic isolation if contamination detected
- Air emissions monitoring (if required by environmental permit):
  - Tank vent emissions (VOC monitoring if required)

- Loading vapor recovery efficiency

M97: Monitoring System Reliability

- All detection and monitoring systems designed for high reliability:
  - Redundant sensors for critical measurements (per chapter 2.3)
  - Fail-safe design: sensor failure generates alarm
  - Backup power (UPS) for critical detection systems
  - Self-diagnostics: systems report faults and malfunctions
- System availability targets:
  - Gas detection: 98% uptime minimum
  - Fire detection: 99% uptime minimum
  - Critical process monitoring (level, pressure): 99.5% uptime minimum
- System downtime documented; extended outages investigated and corrective actions implemented.

M98: Integration with Control and Safety Systems

- Detection systems integrated with facility control and safety systems (per chapter 2.3):
  - Gas detection alarms displayed in control room
  - Fire detection triggers emergency response protocols
  - Leak detection initiates isolation and containment actions
- Integration allows coordinated response:
  - High gas concentration → stop loading + close valves + activate alarms
  - Fire detection → activate suppression + notify fire department + initiate evacuation
- Integration architecture maintains independence of safety systems from process control (separate safety PLC or dedicated safety system).

M99: Operator Interface and Alarm Management

- All detection and monitoring alarms presented to operators via HMI (per chapter 2.3).
- Alarm management:
  - Alarms prioritized: critical (immediate action required), high (prompt action), low (monitoring)

  - Alarm rationalization: avoid alarm floods; suppress non-critical alarms during known transients
  - Alarm acknowledgement required; alarms remain visible until condition corrected
- Operators trained on alarm response (per M79); alarm response procedures documented

2.7 Inspection, Maintenance and Testing

Scope: Periodic inspection requirements, maintenance programs and testing protocols

M100: Inspection and Maintenance Program

- Comprehensive inspection and maintenance program established for all methanol storage and handling equipment.
- Program based on a risk-based inspection approach according to EN 16991 and recognised industry guidance for above-ground storage tanks (e.g. EEMUA 159), supplemented by manufacturer recommendations and applicable regulatory requirements.
- Program defines inspection and maintenance schedules, required competencies of inspection personnel, and documentation procedures in accordance with EN 13460 (maintenance documentation) or equivalent.
- Inspections performed by suitably qualified and competent personnel (e.g. certified tank inspectors, certified welding inspectors, or manufacturer-trained technicians) appropriate to the scope of work.
- Program reviewed and updated at least annually and after significant modifications, incidents, or changes in operating conditions

M101: Tank External Inspection

- Annual visual inspection of atmospheric storage tanks:
  - Tank shell: corrosion, distortion, dents, cracks
  - Roof: damage, ponding water, structural integrity
  - Foundation: settlement, cracking, deterioration
  - External coatings: condition assessment
  - Appurtenances (ladders, platforms): structural integrity
- Settlement monitoring: shell circumference measured annually at multiple elevations; excessive settlement (>1:200 slope) investigated.
- Inspection documented with photographs; deficiencies categorized and corrective actions prioritized.

M102: Tank Internal Inspection

- Internal inspection frequency: every 10 years maximum; more frequently based on risk assessment or corrosion rate.
- Inspection scope:
  - Tank bottom: ultrasonic thickness testing (UT); minimum 20% coverage
  - Shell plates: visual inspection; UT at representative locations
  - Roof underside: visual inspection; structural assessment
  - Internal coatings (if present): condition and thickness assessment
  - Internal floating roof (if present): pontoon integrity, seal condition, fittings
- Tank entry per confined space procedures; isolated, drained, cleaned, ventilated, and gas-tested (oxygen >19.5%, methanol <0.6% = 10% LEL).
- Inspection report documented; repair recommendations prioritized; submitted to regulatory authority if required.

M103: Tank Bottom Integrity

- Bottom plate minimum thickness for new construction in accordance with the applicable tank design standard (e.g. EN 14015) and project specification; for atmospheric methanol storage tanks, new floor plates are typically in the range of 5–6 mm including any specified corrosion allowance.
- Minimum remaining (retirement) thickness of the bottom determined by a risk-based integrity assessment in line with EN 16991 and recognised tank inspection guidance (e.g. EEMUA 159); in practice.
- Bottom inspection performed by internal inspection during planned outages or by suitable in-service methods (e.g. vacuum box testing, acoustic emission, magnetic flux leakage, ultrasonic floor scanning).
- Leak detection provided by monitored secondary containment (e.g. double-bottom with leak detection) and/or groundwater monitoring wells where required by the site's environmental permit.
- Bottom repairs carried out by welded patches or insert plates for localised corrosion, and by sectional or complete bottom replacement in case of widespread deterioration, in accordance with recognised tank repair guidance such as EEMUA 159.

M104: Piping Inspection

- Above-ground piping:

  - Monthly: visual inspection during operations for leaks, corrosion, support condition
  - Annually: detailed visual inspection; coating assessment; valve and flange inspection
- Underground piping:
  - Cathodic protection monitoring: potential measurements at test stations annually (per EN 12954)
  - External inspection during excavation if exposed
- Piping thickness testing: ultrasonic measurements at representative locations; every 5 years minimum; high-risk areas (elbows, tees) prioritized.
- CUI: insulation removed at representative locations (5-10%); visual inspection and UT testing.

M105: Valve Inspection and Testing

- Manual valves: annual operation test (full stroke); stem packing adjusted if leaking.
- Automated valves (ESD, control valves):
  - Quarterly: partial stroke test
  - Annually: full stroke test; response time measurement; actuator inspection
- Relief valves: inspection every 3-5 years; removed and bench-tested; set pressure verified.
- Check valves: annual functional test; internal inspection every 3-5 years.
- Inspection results recorded; deficiencies corrected before return to service.

M106: Pump Inspection and Maintenance

- Centrifugal pumps:
  - Daily: visual and auditory check during operation
  - Monthly: vibration measurement and trending
  - Annually: coupling inspection; seal inspection; bearing lubrication
  - Every 3-5 years: internal inspection; impeller and wear ring assessment
- Magnetic drive pumps: quarterly temperature monitoring; annual internal inspection.
- Pump performance monitoring: flow rate, discharge pressure, power consumption trended; degradation indicates maintenance required.
- Maintenance records: operating hours, parts replaced, performance data documented.

M107: Loading Equipment Inspection

- Loading arms (truck, rail, marine):
  - Before each use: visual inspection for damage, leaks
  - Monthly: swivel joints, couplings, breakaway devices, position interlocks inspected
  - Annually: load test of breakaway coupling; balance system adjustment
- Hoses and flexible connections:
  - Before each use: visual inspection
  - Annually: pressure test at 1.5× working pressure
  - Replacement: every 5 years maximum
- Inspection findings and test results documented.

M108: Instrumentation Calibration

- Instrument calibration per schedule:
  - Level transmitters: annually
  - Pressure transmitters: annually
  - Temperature sensors: biennially
  - Flow meters: annually
  - Gas detectors: monthly bump test and calibration
- Calibration against traceable reference standard; adjusted to within tolerance (typically ±1% of span).
- Calibration certificates issued; records maintained minimum 5 years.
- Out-of-tolerance instruments: investigated; repaired or replaced if beyond adjustment capability.

M109: Safety Instrumented System (SIS) Testing

- Safety instrumented systems tested per IEC 61508/61511:
  - SIL 1: every 2-3 years
  - SIL 2: every 1-2 years
- Proof test procedure: sensor tested, logic solver tested, final element tested (valve stroke, closure time measurement).
- Proof test documentation: results recorded; failures corrected; test interval adjusted if necessary.

M110: Electrical and Grounding System Inspection

- Electrical systems:
  - Annually: infrared thermography of electrical panels; hazardous area equipment inspection
  - Every 3 years: detailed inspection; insulation resistance testing; protective relay testing
- Grounding system:
  - Annually: ground resistance measurement at facility ground grid and tank grounding points; maximum 10 ohms (preferably <1 ohm)
- Emergency power systems (generators, UPS): monthly functional test; annual load bank test.

M111: Fire Protection System Inspection

- Fire water system:
  - Monthly: visual inspection of hydrants, valves, accessibility
  - Annually: functional test; hydrants flowed; pump performance test; valve inspection
- Fire suppression systems (if installed): foam concentrate tested annually; actuating devices tested; nozzles inspected.
- Fire extinguishers: monthly visual inspection; annual maintenance per EN 3.
- Inspection per CEA 4001.

M112: Structural Inspection

- Tank foundations and support structures: annual visual inspection for settlement, cracking, deterioration.
- Pipe supports and racks: annual visual inspection for corrosion, loose bolts, settlement.
- Ladders, platforms, stairs: annual inspection per EN ISO 14122.
- Structural deficiencies evaluated by engineer; repairs prioritized.

M113: Coating and Painting Maintenance

- External coatings:
  - Annually: visual inspection for rust, blistering, peeling
  - Repainting: every 5-7 years typical; spot repairs as needed
- Internal coatings (if present): inspection during internal tank inspection; recoating if deteriorated.

- Surface preparation before repainting per coating manufacturer specification.

M114: Inspection and Maintenance Records

- All inspection, maintenance, and testing documented:
  - Inspection reports: date, inspector, findings, photographs, recommendations
  - Maintenance records: work performed, parts replaced, completion date
  - Test results: calibration certificates, pressure tests, functional tests
  - Deficiency tracking: corrective actions, responsible person, completion date
- Records organized by equipment; accessible for audits.
- Record retention: inspection/maintenance records minimum 10 years; as-built drawings indefinitely.

2.8 Emergency Preparedness and Response

Scope: Emergency plans, protective equipment, firefighting systems, spill response, and crisis management

M115: Emergency Response Plan

- Comprehensive emergency response plan developed, documented, and maintained for methanol facility.
- Plan addresses credible emergency scenarios:
  - Fire (tank fire, pool fire, equipment fire)
  - Spill or release (liquid methanol release, vapor cloud)
  - Personnel exposure (inhalation, skin contact, ingestion)
  - Natural disasters (earthquake, flood, extreme weather)
  - Security incidents (sabotage, unauthorized access)
- Plan includes:
  - Roles and responsibilities (incident commander, emergency responders, support personnel)
  - Notification and communication procedures (internal, external, regulatory authorities)
  - Evacuation procedures and assembly points
  - Emergency equipment locations and operation
  - Coordination with external emergency services (fire department, medical, environmental response)
  - Post-incident procedures (investigation, recovery, remediation)
- Plan submitted to competent authority (fire department, port authority, environmental agency) for approval where required by regulation.
- Plan reviewed and updated annually; revised after incidents or facility changes.

M116: Emergency Training and Drills

- All personnel trained on emergency response procedures:
  - Initial training before assignment to methanol operations
  - Annual refresher training minimum

    - Training includes recognition of emergency conditions, alarm response, evacuation routes, assembly points
- Emergency drills conducted:
    - Fire drill: annually minimum; tests evacuation, alarm systems, fire brigade response
    - Spill response drill: annually minimum; tests spill containment, cleanup procedures, notifications
    - Tabletop exercises: scenarios discussed and response procedures reviewed
- Drills documented: participants, scenario, observations, improvement actions identified.
- External emergency services (fire department) invited to participate in drills.

M117: Methanol Fire Characteristics and Detection

- Critical safety information: Methanol burns with nearly invisible, pale blue flame in daylight; difficult to see without thermal imaging equipment.
- Fire detection methods:
    - Flame detectors: UV/IR or multi-spectrum type; detect invisible methanol flame (per chapters 2.3 or 2.6)
    - Heat detectors: backup for flame detection
    - Thermal imaging cameras: recommended for emergency responders to visualize methanol fires
- Personnel awareness:
    - Training emphasizes invisible flame hazard
    - Approach suspected fire areas with caution; use thermal imaging or heat sensation test (radiated heat felt before flame seen)
    - Never assume area is safe because no visible flame

M118: Fire Extinguishing Methods

- Methanol fire extinguishing agents:
    - Alcohol-resistant foam (AR-AFFF): primary method for large fires; forms vapor-suppressing blanket on methanol surface
    - Dry chemical (ABC or BC type): effective for small fires; does not prevent re-ignition
    - Carbon dioxide (CO_2): effective in enclosed spaces; higher concentration required than for hydrocarbon fires

    - Water spray (fog pattern): can be used for cooling or dilution; large quantities required (minimum 4:1 water-to-methanol ratio to render non-flammable)
- Methods NOT effective:
    - Standard aqueous film-forming foam (AFFF): destroyed by methanol; alcohol-resistant type required
    - Water jet (solid stream): spreads fire; only fog pattern acceptable
- Small fires (portable extinguisher range): dry chemical extinguisher (minimum 43A/233B rating per M126).
- Large fires: alcohol-resistant foam applied by fire department or facility fire brigade; water spray for cooling adjacent tanks/equipment.

M119: Personal Protective Equipment - Emergency Response

- Emergency PPE available at strategic locations:
    - Full face shield or splash goggles
    - Chemical-resistant gloves (butyl rubber preferred for methanol)
    - Chemical-resistant suit or apron
    - Emergency escape respirator (air-purifying with organic vapor cartridge) or self-contained breathing apparatus (SCBA)
- PPE for spill response and firefighting:
    - Fire brigade: full structural firefighting gear (coat, pants, helmet, boots, gloves); SCBA mandatory
    - Spill response team: chemical-resistant suit (Level B); SCBA or supplied-air respirator; chemical-resistant boots and gloves
- PPE inspection and maintenance: monthly inspection; damaged equipment replaced; SCBA air cylinders refilled after use and annually.
- Training on PPE donning, use, limitations, and decontamination.

M120: Emergency Decontamination and First Aid

- Decontamination facilities:
    - Safety showers: located at loading areas, pump stations, tank access points; frost-free or heat-traced; water temperature 15-37°C; flow rate minimum 75 liters/minute
    - Eyewash stations: located with safety showers; flow rate minimum 6 liters/minute; tested weekly
- First aid procedures for methanol exposure:

  - Skin contact: remove contaminated clothing; flush skin with large quantities of water for minimum 15 minutes; seek medical attention
  - Eye contact: flush eyes with water or eyewash for minimum 15 minutes; remove contact lenses if present; seek immediate medical attention
  - Inhalation: move person to fresh air; seek medical attention; provide oxygen if available and trained
  - Ingestion: do NOT induce vomiting; seek immediate medical attention (methanol ingestion can cause blindness or death)
- Medical treatment information: methanol poisoning treated with ethanol or fomepizole as antidote; prompt medical treatment critical.
- First aid supplies: maintained at facility; first aid trained personnel on-site during operations.

M121: Spill Response Procedures

- Immediate actions upon spill discovery:
  - Alert personnel; activate alarm if necessary
  - Stop source of spill if safe to do so (close valve, stop pump)
  - Eliminate ignition sources (no smoking, engines off, isolate electrical equipment)
  - Evacuate non-essential personnel from spill area
  - Don appropriate PPE before approaching spill
- Spill containment:
  - Small spills (<50 liters): absorb with absorbent material (sand, vermiculite, commercial absorbent pads)
  - Large spills (>50 liters): contain with dikes, berms, or absorbent booms; prevent entry to drains, sewers, or water bodies
  - Spilled methanol collected in containers; disposed per hazardous waste regulations
- Vapor control:
  - Water spray (fog pattern) to knock down vapors; direct spray away from spill to avoid spreading liquid
  - Ventilation of enclosed areas
- Cleanup:
  - Contaminated soil or absorbent material collected and disposed as hazardous waste
  - Area flushed with water; contaminated water sent to treatment system
  - Air monitoring confirms area safe before permitting re-entry

- Spill response equipment: spill kits, absorbent materials, protective equipment pre-positioned at strategic locations.

M122: Environmental Protection During Emergencies

- Prevent environmental contamination:
  - Spilled methanol contained within secondary containment (dikes) or prevented from entering storm drains, sewers, or water bodies
  - Drain valves closed during emergency to prevent release beyond facility boundary
  - Booms deployed in water bodies if methanol reaches drainage ditches or waterways
- Notification requirements:
  - Environmental authorities notified immediately if methanol released beyond facility boundary or enters water body
  - Quantity released estimated; environmental impact assessed
- Remediation:
  - Contaminated soil excavated and disposed if necessary
  - Groundwater monitoring initiated if subsurface contamination suspected
  - Surface water monitoring downstream if waterway impacted

M123: Firefighting Water System Design - Cooling and Protection

- Firefighting water system designed primarily for COOLING exposed equipment and tanks during fire, NOT for extinguishing methanol fires.
- System capacity calculation:
  - Tank fire: water application rate minimum 10 L/min/m^2 of tank surface
  - Duration: minimum 4 hours continuous supply
  - Example: 1000 m^2 tank surface × 10 L/min/m^2 × 240 minutes = 2,400 m^3 water required
- System components:
  - Water supply: dedicated storage tank, connection to municipal water, or reliable natural source (river, sea)
  - Fire pumps: minimum two pumps (duty and standby); automatic start on pressure drop; combined capacity meets demand
  - Distribution network: loop system with isolation valves; designed per EN 12845 or equivalent
  - Fire hydrants: spacing 50-80 meters; connections minimum DN65 (Storz coupling or equivalent)

- System design per EN 12845, EN 14816, or equivalent European standards.

M124: Firefighting Water System Maintenance

- Monthly inspection: hydrants, valves, accessibility verified.
- Annual functional test: hydrants flowed; pump performance tested (flow vs. pressure curve verified); system pressure at most remote hydrant measured.
- Weekly pump test: pumps started and run briefly; fuel level checked (diesel pumps); battery condition verified (electric start).
- System maintained frost-free in cold climates: drain valves, heat tracing, or insulation as appropriate.
- Test results documented; deficiencies corrected promptly.

M125: Fixed Fire Suppression Systems (if applicable)

- Fixed foam systems for large atmospheric tanks (if required by risk assessment or regulation):
  - Foam type: alcohol-resistant concentrate (AR-AFFF or fluoroprotein)
  - Application rate: per EN 13565 (typically 4-6 L/min/m^2 of tank surface)
  - Foam delivery: fixed foam chambers on tank rim or foam generators
  - Foam concentrate supply: adequate quantity for design application duration (typically 30 minutes)
- Deluge systems for loading areas or equipment (if required):
  - Water spray nozzles covering equipment
  - Automatic actuation by fire detection or manual activation
  - Design per EN 14816
- Systems tested annually: foam concentrate quality verified; foam expansion ratio tested; actuation devices tested; discharge nozzles inspected.

M126: Portable Fire Extinguishers

- Portable extinguishers located at:
  - Loading/unloading areas: minimum one per bay
  - Pump stations: minimum one per pump
  - Tank access points: minimum one per tank
  - Control rooms and buildings
  - Emergency equipment cabinets
- Extinguisher type and rating:

  - Dry chemical (ABC or BC type): minimum 43A/233B rating
  - CO_2 extinguishers: acceptable for electrical fires; minimum 5 kg capacity
- Extinguisher spacing: maximum 15 meters travel distance from any point to nearest extinguisher.
- Extinguishers inspected monthly (visual check); maintained annually per EN 3; hydrostatic test per schedule (typically 12 years for dry chemical).
- Personnel trained on extinguisher use; "PASS" method (Pull, Aim, Squeeze, Sweep) emphasized.

M127: Vapor Dispersion Control

- Vapor dispersion systems at loading areas (if required by risk assessment):
  - Water curtain: ring of spray nozzles surrounding loading area; activates automatically on gas detection or manually; total nozzle capacity (TNC) designed to contain and dilute vapor cloud
  - Water monitors: remotely controlled high-capacity nozzles (minimum 2000 L/min each); minimum two per loading bay; directed at vapor source
- System activation:
  - Automatic: triggered by gas detection alarm (high-level alarm per chapter 2.6)
  - Manual: push-button at control room and local safe locations
- System capacity sufficient to control credible vapor release scenarios; design per facility risk assessment and local fire code.

M128: Emergency Communication Systems

Communication infrastructure per M42 applies, with the following emergency-specific requirements:

- Dedicated emergency channel:
  - Separate radio frequency reserved for emergency communications only
  - Channel tested monthly; all emergency responders trained on use
- Pre-recorded emergency messages:
  - Standardized PA announcements for: fire, evacuation, gas release, shelter-in-place
  - Messages available in local language(s) and English
  - Activation from control room and backup location
- Distinct alarm tones:
  - Audible and visual alarms at strategic locations

    - Different tones for different emergencies (fire, evacuation, spill)
    - Alarm meaning posted at all work areas
- External emergency contacts:
    - Emergency services (fire, ambulance, police) on speed dial
    - Regulatory authorities (environmental agency, port authority) contact list posted
    - Management on-call list maintained and updated weekly
- Redundancy and testing:
    - Backup power (UPS or generator) for all emergency communication systems
    - Monthly communication system tests documented

M129: Evacuation Procedures and Assembly Points

- Evacuation routes clearly marked; minimum two independent routes from each work area.
- Evacuation triggers:
    - Fire alarm activation
    - Gas detection high-alarm
    - Emergency announcement via PA system
    - Siren or air horn (audible throughout facility)
- Evacuation procedure:
    - Personnel immediately cease operations (safe shutdown if time permits)
    - Proceed to nearest exit; do not use elevators
    - Report to designated assembly point
    - Remain at assembly point until accountability complete and clearance given
- Assembly points:
    - Located upwind and minimum 100 meters from facility
    - Clearly marked with signs
    - Protected from weather (shelter or designated building)
- Accountability: supervisors verify all personnel accounted for; report missing persons to incident commander immediately.
- Evacuation drills conducted annually (per M116).

M130: Wind Indication

- Wind direction indicator (wind sock or wind vane) installed at facility; visible from control room and key outdoor locations.

- Wind sock illuminated for night visibility.
- Wind direction critical for:
  - Evacuation planning (move upwind from spill or vapor release)
  - Vapor dispersion prediction
  - Firefighting operations planning

M131: Emergency Shutdown Procedures

- Emergency shutdown (ESD) initiated when:
  - Fire detected or reported
  - Major leak or spill
  - Safety system failure
  - Natural disaster (earthquake, severe weather)
- ESD actions (per chapter 2.3):
  - Stop all transfer operations
  - Close automated isolation valves
  - Stop pumps
  - Activate alarms
  - Notify emergency services
- ESD activation: manual push-buttons at control room and minimum two field locations (near tanks, loading areas).
- Post-ESD: facility inspected for damage; system integrity verified before restart.

M132: Fire Brigade (if applicable)

- Facility fire brigade established for large facilities or where public fire department response time exceeds 10 minutes.
- Coordination with public fire department: memorandum of understanding defines roles, responsibilities, command structure during emergencies.

M133: Post-Incident Investigation and Reporting

- All emergency incidents investigated:
  - Incident investigation team: facility management, safety officer, operations personnel, subject matter experts as needed
  - Investigation timeline: initiated within 24 hours; report completed within 30 days

    - Investigation includes: incident timeline, root cause analysis, contributing factors, corrective actions
- Regulatory reporting:
    - Immediate notification: fire department, environmental agency, port authority per regulatory requirements
    - Written report: submitted within timeframe specified by regulation (typically 7-30 days)
    - Report includes: incident description, quantity released, environmental impact, corrective actions
- Lessons learned:
    - Findings communicated to all personnel
    - Corrective actions tracked to completion
    - Emergency response plan and procedures updated if necessary

M134: Mutual Aid Agreements

- Mutual aid agreements established with neighboring facilities for emergency support:
    - Fire suppression assistance (equipment, personnel, foam supplies)
    - Emergency shelter for evacuated personnel
    - Backup communication systems
    - Emergency equipment loan (pumps, generators, spill response equipment)
- Agreements documented in writing; contact lists maintained and updated; tested periodically through joint drills.

M135: Emergency Equipment Locations and Lighting

- Emergency equipment locations marked on facility emergency maps; posted in control room and at entry points.
- Emergency lighting:
    - Portable lights and flashlights with spare batteries at strategic locations
    - Battery-powered emergency lights in control room, pump stations, and loading areas
- Reference: For specific equipment requirements see M119 (Emergency PPE), M120 (First Aid), M121 (Spill Response Kits), M126 (Fire Extinguishers).

2.9 Modern Requirements

Scope: Cybersecurity, climate resilience, and modern security threats

M136: Industrial Cybersecurity for Control Systems

- Industrial control systems (Supervisory Control and Data Acquisition (SCADA), Distributed Control System (DCS), PLC) and safety instrumented systems protected per IEC 62443, NIS2 Directive (Art. 21) or equivalent.
- Network segmentation:
  - Operational technology (OT) separated from information technology (IT)
  - Firewall at OT/IT boundary
  - Safety systems (SIS) isolated from process control where practical
- Access control:
  - User authentication and role-based permissions
  - Multi-factor authentication for remote access
  - VPN required for external connections
  - Session logging maintained
- Physical security of control hardware:
  - PLCs, servers, networking equipment in locked cabinets or control room
  - Access logging for control room and equipment areas
- Security maintenance:
  - Regular security updates and patches per vendor recommendations
  - Vulnerability assessments annually minimum
  - Security incidents investigated and documented
- Backup systems:
  - Control configurations backed up offline (not network-connected)
  - Backups tested quarterly
  - Recovery procedures documented

Recommendation:

- Encrypted wireless protocols and key rotation are strongly recommended, particularly if wireless links are operational.
- A documented cybersecurity incident response plan specific to industrial control systems should be maintained and regularly tested.

M137: Cybersecurity - Emergency Control Independence

- Critical safety functions independent of control systems:
  - Manual emergency shutdown pushbuttons (hardwired, not through PLC)
  - Manual valve operation capability (handwheels on critical valves)
  - Backup manual level indication (sight glasses, dip sticks)
- Cybersecurity incident response:
  - Procedures for control system compromise
  - Manual operation capability until systems restored
  - Emergency shutdown independent of compromised systems
- Personnel training on cybersecurity awareness: phishing recognition, password security, suspicious activity reporting.

M138: Climate Resilience - Design Parameters

- Facility design accounts for climate change projections (IPCC AR6):
  - Temperature extremes: design for +10°C above historic maximum and -10°C below historic minimum
  - Wind loads: 150% of current local design wind speed standards (EN 1991)
  - Precipitation: drainage systems sized for 100-year storm plus 25% margin
- Flood protection (if facility in projected 100-year flood zone):
  - Critical equipment elevated above projected flood level
  - Waterproof barriers for below-grade infrastructure
  - Emergency drainage capacity with backup power
- Sea level rise (coastal facilities):
  - Long-term planning accounts for 0.5-1 meter sea level rise over facility lifetime
  - Critical infrastructure elevated or protected accordingly
- Climate risk assessment updated every 5 years or after severe weather events.

M139: Extreme Weather Preparedness

- Severe weather monitoring and response:
  - Weather alert system providing real-time warnings
  - Pre-storm procedures: secure loose items, verify backup power, test emergency systems
  - Operations curtailment criteria defined (wind speed thresholds, storm warnings)

- Post-storm inspection:
  - Facility inspected for damage before resuming operations
  - Structural integrity, tank stability, piping, electrical systems verified
- Extended power outage preparedness:
  - Emergency generator fuel supply for 72 hours minimum
  - Manual monitoring procedures for extended outages
  - Alarm systems connected to security response

M140: Physical Security - Critical Infrastructure Protection

- Control room hardening:
  - Backup control capability at separate location if control room compromised
  - Emergency systems (ESD, fire suppression) protected and redundant
- Drone countermeasures (optional, for high-risk facilities):
  - Drone detection systems (radar, RF, visual)
  - Response protocols for unauthorized drone activity
  - Coordination with local authorities
- Personnel security measures:
  - Visitor registration and escort in operational areas
  - Access control cards or keys tracked and controlled
  - Contractor access limited to authorized areas and supervised
- Emergency lockdown capability:
  - Procedures for security threats
  - Secure access control at all entry points
  - Communication capability to alert personnel and authorities

M141: Sustainability Assessment and Life Cycle Considerations

- Major infrastructure projects subject to sustainability assessment per EU Taxonomy requirements:
  - New storage tanks or significant modifications
  - New loading/unloading infrastructure
  - Projects seeking EU green financing or public funding
- Carbon footprinting per ISO 14067 or EN 17472:
  - Scope 1: Direct emissions from facility operations
  - Scope 2: Indirect emissions from purchased energy
  - Scope 3: Embodied carbon in materials, transport, construction
- EU Taxonomy environmental objectives considered:

    - Climate change mitigation (primary)
    - Climate change adaptation
    - Circular economy (material reuse, recycling)
    - Pollution prevention
    - Water and marine resource protection
- Construction and demolition waste (CDW):
    - Minimum 70% reuse or recycling of non-hazardous CDW per EU Taxonomy
    - Material recovery plan documented before construction
- Material selection informed by environmental assessment:
    - Recyclable materials prioritized where technically feasible
    - Environmental Product Declarations (EPDs) per EN 15804 requested from suppliers for major components
    - Results documented and considered in design decisions
- Assessment documentation retained for facility lifetime; updated for major modifications.

Note: Full Life Cycle Assessment (LCA) per ISO 14040/14044 and EN 17472 recommended for projects >€5 million or where required by funding conditions, environmental permits, or corporate ESG commitments.

3 References

- DNV: Alternative Fuels Insight Tool
- EIGA Doc 75/21 Methodology for determination of safety and separation distances
- EN 1092-1: Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories
- EN 12954: Cathodic Protection of Buried or Immersed Metallic Structures
- EN 13480: Metallic Industrial Piping
- EN 13565: Fixed Firefighting Systems - Foam Systems
- EN 14015: Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks
- EN 3: Portable Fire Extinguishers
- EN 60079 series: Explosive Atmospheres (Equipment and Protection Systems)
- EN ISO 14122: Safety of Machinery - Permanent Means of Access to Machinery
- EN ISO 15614-1: Specification and qualification of welding procedures for metallic materials
- EU Taxonomy Regulation (2020/852): Sustainable Finance
- Eurocode 1 (EN 1991): Actions on Structures
- Eurocode 8: Design of structures for earthquake resistance
- IEC 61508: Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems
- IEC 61511: Functional Safety - Safety Instrumented Systems for the Process Industry Sector
- IEC 62443: Industrial Communication Networks - Network and System Security
- IPCC AR6: Sixth Assessment Report of Climate Change
- ISO 14040: Environmental Management - Life Cycle Assessment - Principles and Framework
- ISO 14044: Environmental Management - Life Cycle Assessment - Requirements and Guidelines
- ISO 14726: Ships and Marine Technology - Identification Colours for the Content of Pipes
- ISO 45001: Occupational Health and Safety Management Systems
- ISO 6583:2024 Methanol as a fuel for marine applications
- ISO 9606: Qualification testing of welders
- Methanol Institute: Atmospheric Above Ground Tank Storage of Methanol
- Methanol Institute: Compatibility of Elastomers in Neat Methanol Service
- Methanol Institute: Compatibility of Metals & Alloys in Neat Methanol Service
- Methanol Institute: Safe Handling Manual (5th Edition)

- OCIMF: Oil Companies International Marine Forum - Guidelines for Marine Loading Arms
- Perplexity.ai, Claude.ai: As a summary tool; The content reflects the project's activities. AI were used for the generation of the cover page, and no personal data was used for this purpose.
- PGS 15: Storage of packaged hazardous substance

4 Abbreviations and Acronyms

- AED: Automated External Defibrillator
- AR-AFFF: Alcohol-Resistant Aqueous Film-Forming Foam
- CCTV: Closed-Circuit Television
- CUI: Corrosion Under Insulation
- DCS: Distributed Control System
- DN: Diameter Nominal
- EN: European Norm / European Standard
- EPDM: Ethylene Propylene Diene Monomer
- ERC: Emergency Release Coupling
- ESD: Emergency Shutdown
- ESG: Environmental, Social, and Governance
- GHS: Globally Harmonized System
- HDPE: High-Density Polyethylene
- HHLA: High-High Level Alarm
- HLA: High-Level Alarm
- HMI: Human-Machine Interface
- IEC: International Electrotechnical Commission
- IPCC: Intergovernmental Panel on Climate Change
- ISO: International Organization for Standardization
- IT: Information Technology
- LCA: Life Cycle Assessment
- LEL: Lower Explosive Limit
- MOC: Management of Change
- MT: Magnetic Particle Testing
- OCIMF: Oil Companies International Marine Forum
- OT: Operational Technology
- P&ID: Piping and Instrumentation Diagram
- PA: Public Address
- PLC: Programmable Logic Controller
- PN: Pressure Nominal (flange rating)
- PPE: Personal Protective Equipment
- PTFE: Polytetrafluoroethylene (Teflon)
- RF: Radio Frequency
- RT: Radiographic Testing
- SCADA: Supervisory Control and Data Acquisition
- SCBA: Self-Contained Breathing Apparatus
- SIL: Safety Integrity Level
- SIS: Safety Instrumented System

- TNC: Total Nozzle Capacity
- TRV: Thermal Relief Valve
- UEL: Upper Explosive Limit
- UPS: Uninterruptible Power Supply
- UT: Ultrasonic Testing
- UV/IR: Ultraviolet/Infrared
- VFD: Variable Frequency Drive
- VOC: Volatile Organic Compounds
- VPN: Virtual Private Network
- ppm: Parts per million