



**SAMPLE SPECIFICATION
FOR
UNDERTANK HEATING SYSTEMS
WITH
TYPE FP CONSTANT WATT
HEATING CABLE**

October 2007

SPECIFICATION FOR UNDERTANK HEATING SYSTEMS

INTRODUCTION:

Industrial, commercial and agricultural chemical facilities often require storage of product at cryogenic and low temperatures (i.e. substantially below a freezing temperature of 0°C) in storage tanks and other low pressure vessels. Because of the sub-freezing temperatures internal to the vessel, freezing and subsequent thawing of the soil below and/or around the vessel can occur. This in turn, can result in heaving of the soil and subsequent damage to the structure foundations.

The most common methodology in dealing with this phenomenon is to provide a combination of thermal insulation and supply of external heat as listed below:

- (1) Install a non-hygroscopic insulation between the soil and vessel/foundation structure and,
- (2) Install electric heat tracing in conduits beneath the insulation in the soil, sand or concrete supporting the insulation and vessel structure.

These specifications detail a design methodology for undertaking heating.

1. General

- 1.1 Where an undertank heating system is required to prevent freezing of the tank subsoil, it shall be an electrical system in accordance with this specification and shall be in accordance with general project specifications.
- 1.2 The system shall be complete from the point of power supply and shall provide all necessary functions, including undertank heating, electrical power distribution and circuit protection alarms, temperature sensing, temperature control and monitoring separately for each tank. The project specifications shall clearly define the scope of work with respect to battery limits for tank vendor and general contractor.
- 1.3 System components shall be approved by a recognized testing laboratory, such as Underwriters Laboratories (UL), Factory Mutual (FM), DEMKO, CSA, or KEMA for the specified area classification. Heaters shall be approved for Zone 1 and Class I, Division 2 locations, as a minimum, and shall meet the cable construction requirements of IEEE Standard 515. Preference shall be given to vendors with ISO 9001 approval for critical components such as heaters and controllers.

2. Heater Design and Materials

- 2.1 The heater cable shall have proven capability in cryogenic and/or refrigerated base heating installations, as applicable. In general, selection shall be limited to parallel resistance, constant wattage heating cable. Heating cables having high in-rush characteristics when cold or exposed to moisture in the conduit (such as self-regulating cable) are not preferred for this application.
- 2.2 Heater cables shall be manufactured by companies that have produced cables and designed systems for undertank heating systems for at least ten (10) years and have FM approval and IEC Ex certification for their product.
- 2.3 Constant wattage parallel resistance heater cables shall be provided with fluoropolymer insulation, nickel-plated copper braid, and fluoropolymer outer sheath. The heater cable bus wires shall be 4 mm² (12 AWG) minimum. The grounding path (braid) shall be equivalent to the cable bus wire with respect to current carrying capacity. Wherever possible, heater cable shall be capable of direct connection to 480 volt supply.

3. Design Considerations

- 3.1 Calculated heat load shall be increased by a minimum safety factor of 50% to account for variations in items such as insulation conductivity, voltage, and soil conditions over the system's service life.
- 3.2 Any large nozzle pit areas or other areas requiring special heating shall be considered as separate zones from the main area under the tank.
- 3.3 For tanks located in cold climate regions, ring wall heating with separate zone control should be considered.
- 3.4 Heating circuits for each zone shall be connected to provide a balanced three-phase load. Preference will be given for direct connection to 480 volt supply.
- 3.5 Using proportional control or power clamping the heaters are energized with effectively continuous power. However, if one circuit conduit is lost, the heating system shall be capable of delivering additional heat without changing power supply. This will be

accomplished by using a control/monitoring system described in Section 5.0.

4. Protective Devices

- 4.1 A main distribution panelboard containing circuit breakers with an overcurrent and a ground-fault equipment protective device (30 mA to 100 mA) and trip indication for each outgoing circuit shall be provided. A common remote alarm shall be provided to indicate loss of voltage to any branch circuits. If the controller provides ground fault monitoring, it is not necessary to provide ground-fault circuit breakers.
- 4.2 Heater cable circuits shall be designed to have a total earth leakage not exceeding 60 percent of the ground fault leakage protection trip value to prevent nuisance tripping.

5. Control and Monitoring

- 5.1 A minimum of two sensors shall be provided under each zone for control and monitoring. The sensors shall be three wire RTD's (100 Ohms @ 0°C) with $\pm 1\%$ repeatable accuracy and shall be water resistant/sealed.
- 5.2 A microprocessor based temperature control and monitoring controller shall be utilized with RTD sensors. A multi-point module providing proportional control, digital information display and alarms for high temperature, low temperature, high current, low current, high ground leakage current and damaged temperature sensor shall be used. Controller shall be connected downstream of the circuit breakers. Each output segment shall be capable of power output adjustments utilizing zero crossing solid state relays to maintain system power quality.
- 5.3 The controller/solid state relay design shall be capable of providing power level adjustment. The power adjustment level shall be selected so that heaters are energized continuously at a percentage of total power while maintaining the foundation temperature at setpoint. The power level shall be adjusted in response to changes affecting the required heater output such as:
 - a. Long term changes in ambient weather conditions
 - b. Average ground temperatures
 - c. Ground water characteristics
 - d. Insulation characters
 - e. Specified cryogenic fluid maintain temperature

- 5.4 The operation of the control shall be fail-safe. In the event of a failure (with the exception of a high temperature condition), an alarm will be actuated and the heating system energized.
- 5.5 The maximum current controlled by each relay shall not exceed 80 percent of its continuous ampere rating.
- 5.6 The controllers and indicators shall be remotely mounted unless otherwise indicated. Controllers, when located outdoors, shall be housed in a stainless steel enclosure, free-standing or wall mounted.

6. Conduits

- 6.1 Undertank conduits shall be a minimum of 19 mm (3/4 in.) rigid galvanized steel in accordance with ANSI C80.1. When embedded in sand, the external surface of conduits and seal welds shall be given a single coat of epoxy paint, 0.1 to 0.15 mm (4 to 6 mils) thick for additional corrosion protection.
- 6.2 Conduits shall be installed in clean (salt-free) sand or concrete. This layer shall be normally a minimum of 0.3 m (1 ft.) thick and located above the high-water table. The conduit shall be located at the center of the 0.3 m layer.
- 6.3 Conduit spacing shall not exceed 1 m (3.3 ft.) unless it can be proven by calculations that the requirements of this specification can be met with larger spacing and design should be substantiated by FEA analysis of the temperature distribution between conduits. Conduit bends shall be minimized to assist easy installation and maintenance. However, where unavoidable, they shall have the maximum radius feasible. The minimum radius shall be 10 times the conduit diameter.
- 6.4 Conduits for temperature sensors shall be located parallel to and halfway between adjacent heating conduits, generally near the center of each zone.
- 6.5 The space between the conduits and any pipe sleeves in a concrete ring wall shall be sealed against water entry by means of a non-hygroscopic, pliable material extending at least 10 cm (4 in.) into the space.

- 6.6 Conduits shall slope upward to the tank center to drain to the perimeter and to compensate for the predicted differential settlement between the tank edge and center.

7. Other Equipment

- 7.1 Drains shall be provided with all junction/terminal boxes.
- 7.2 All circuit components shall be suitably sized for maximum cable tolerances.

8. Installation

- 8.1 Just prior to heater pulling, conduits shall be blown free of water and a mandrel and swab shall be pulled through the conduit until the conduit is clean and dry.
- 8.2 Heater cable terminations shall be doubly sealed with a heat shrink/adhesive outer seal for maximum water resistance.

9. Inspection and Testing

- 9.1 Prior to covering or encasing the conduit, it shall be air pressure tested at 100 kPs (15 psig) with a soap solution applied at joints.
- 9.2 Factory and field tests for heater cable in accordance with IEEE Standard 515 or IEC 62086 -1,-2 (IEC 60079-30,-1,-2) shall be performed to ensure long-service life and reliable operation.

Sufficient field test data, such as dielectric insulation resistance and load amperes, shall be taken to provide a base to determine adequacy after installation and during operation.

10. Vendor Data

- 10.1 Documents submitted with the bids shall include the following information:
- (a) Calculated heat flux, and proposed heating cable watt density.
 - (d) FEA results showing soil/slab temperature distribution
 - (e) Assumed thermal conductivity of the various layers on which the calculations are based.

- (f) Total kilowatts used for each zone.
 - (g) Component specifications and descriptive literature
 - (h) General QA/QC procedures.
- 10.2 Additional documents following a bid award shall include:
- (a) Heater arrangement and circuit drawings, including number of zones for separate control, heater spacing, and location.
 - (b) Heater control scheme, including duty cycle, location of sensors, temperature control criteria, and any provision for a forced frequency cycle.
 - (c) Shop and field testing and inspection procedures.
 - (d) Installation and heater replacement instructions
 - (e) Heating calculations, by zone, including tank heat leak shall be supplied using FEA analysis and/or any other acceptable analytical methods.
- 10.3 Test reports shall be submitted progressively as tests are completed.