LEAK DETECTION SYSTEMS FOR TANK FARMS REFERENCE GUIDE

System Description

The main objective of the Liquid Hydrocarbon Detection System shall be to detect hydrocarbon liquids that have escaped their intended confinement structures consisting of pipes, tanks, pumps, valves and other fittings or containers in the Tank Farm facility. The intention of the Liquid Hydrocarbon Detection System is to alert facility staff to the presence of such liquids in situations that could lead to immediate safety risk in the case of explosion or fire and to potential harmful impact on plant personnel or the environment. The intent of the Liquid Hydrocarbon Detection System is to provide and independent safety layer for mitigation of consequences that help achieve overall process safety requirements of the tank farm and to prevent harmful impacts to the environment.

Liquid Hydrocarbon Detection System shall be designed to perform its function during normal, abnormal and design basis conditions.

Control systems using the Liquid Hydrocarbon Detection System output signals shall be based on open architecture system topology with fault tolerant network capabilities.

The system and its components shall be UL listed, FM approved, CSA certified, and tested to Third Party Procedures developed according to the U.S. EPA's "Standard Test Procedures for Evaluating Leak Detection

Liquid Hydrocarbon Detection System shall be based on the following as per detailed scope of work:

Types of Liquid Hydrocarbon Detection Sensors:

- Carbon enriched point detection probes based conductive polymer technology that undergo a rapid change in a measurable electrical property (e.g. probe resistance) when contacted with liquid hydrocarbons at any point of the exposed sensor surface area.
- Carbon enriched sensor cables that absorb a small quantity of any spilled liquid hydrocarbon such that the cable is able to detect the presence of the liquid hydrocarbon via a measurable change in electrical properties of the sensor cable and further indicate the location of the detected spill along the length of the sensor cable to an accuracy of +/- 1 m or +/- 0.1% (whichever is greater).

Control Systems and System Descriptions:

In both the detection probe and sensor cable instance, the sensor device shall be energized and monitored with a Sensor Interface Module capable of providing the required excitation voltage, monitoring the status indicative electrical parameters of the sensor and transmitting the current status of the sensor and location of any detected spill or leak to the control room monitor panel and or host control system.

The energy levels used to energize and monitor the sensor probes or cable shall be within the limits of intrinsically safe operation such that the sensor devices may be installed in in Zone 0 Gas Group IIA (propane) or better.

The Sensor Interface Module shall locally determine the status of any connected sensor devices and interconnect wiring such that leak detection or damaged sensor or wiring shall be determined without ambiguity.

Fuel Detection Probe for Tank Farm Area:

The control system shall generate a liquid hydrocarbon detection alarm within 5 seconds when contacted by Naphtha, Gasoline, Jet Fuel, Diesel and liquid hydrocarbons of similar molecular weight and viscosity. Response time may be longer for heavy fuel oils or heavy crudes where extreme high viscosity and/or cold temperature prevent the oil from reaching the sensor surface.

The fuel detection probes shall be designed in a fail-safe manner such that loss of integrity of the sensor film due to abrasion, mechanical damage or breakage, shall indicate an alarm condition in the control room requiring staff to determine and correct the cause of the alarm including possible replacement of the sensor probe. The probe shall be designed such that it cannot falsely generate a “NORMAL” status when it is incapable of detecting a hydrocarbon leak or spill.

Multiple fuel probes monitored by the same Sensor Interface Module shall be permitted if the Sensor Interface Module is capable of identifying which of the connected probes is generation any leak detection alarm state.

Any loss of continuity of the interconnection wiring between the Sensor Interface Module and the Fuel Sensor Probe or wiring between probes in the case of multiple probe installations shall generate a cable break alarm at the Sensor Interface Module.

The system shall be capable of multiple leak detections and resetting using factory specified cleaning and reset procedures.

The fuel detection probe, Sensor Interface Module, interconnection wiring (including wireless or fiber optic telemetry system if used) and user alarm panel shall be capable of end-to-end periodic wet testing using a small amount of Naphtha brought into contact with any one of the fuel probes installed at the facility.

The probe should be FM approved.

Fuel Detection Sensor Cable for the Fuel Farm:

The control system shall generate a liquid hydrocarbon detection alarm with an average response time as described on the Vendor's product data sheet. Such response times will vary based on the molecular weight, viscosity, volatility, temperature and chemical compatibility of the spilled liquid hydrocarbon and the sensor cable.

The sensor cable shall be designed in such a way that all internal wiring is continuously monitored. Any breakage of an internal conductor or damage or disconnection of a connector or wiring between the sensor interface module and the sensor cable shall be immediately detected and reported to the control room as a "cable break" or "loop break".

The sheath of the sensing cable shall be made of conductive polymer which shall swell in the presence of hydrocarbon liquids thus creating a circuit between the sensing wires within the cable. The measure of change in resistance due to the circuit formation indicates the presence of leak and its location.

The sensor cable shall be equally sensitive to leak spill size at any point along its length and shall generate a leak detection alarm when exposed to no more than 10 ml of spilled fuel. Systems that require a larger spill as the distance from the Sensor Interface Modules or Control Panel are not acceptable.

The sensor cable and Sensor Interface Module shall be capable of determining the location of a detected leak or spill to +/- 1 meter along the length of the sensor cable.

The entire length of the cable shall be sensitive to liquid hydrocarbons such as crude oil products. Leak Detection cables shall be installed in perforated tubes buried under the Tank bottom plate. The perforated (PVC) conduits shall be supplied by Vendor and installed by an Engineering Procurement Installation and Commissioning (EPIC) contractor.

The sensing cables shall be capable of accommodating any number of branches using branching connectors. Jumper cable shall be available to interconnect sensing cables or to facilitate remote mounting of the Sensor Interface Module (SIM). Use of interconnect wiring to remotely mount the SIM shall not reduce the maximum amount of sensor cable the SIM can monitor.

Perforated conduits and pull boxes shall be supplied by same Vendor of leak detection system and shall be installed at fixed intervals (4 meters spacing at a depth of 300mm to 500mm) from the center of the tank bottom in both directions as recommended by the leak detection Vendor. Sensor cable shall be placed from edge to edge (of tank bottom circle). It shall be possible to cut sensor cable to length and terminate in the field.

Leader cable shall be provided with sensor cable connectors on one end, with the other end ready for Connection to the terminal blocks in a SIM by Vendor.

For installations outside the tank bottom plate non perforated conduits shall be used. It shall be possible to install cables using a pull box included in the Vendor scope of supply.

The sensors cable shall be only sensitive to liquid hydrocarbons and should not be sensitive to water and/or other solvents.

Vendor shall provide the following details:

1. Technical and dimensional details of the sensor cable & conduit
2. Maximum sensor cable length the system can monitor
3. Junction box and cable gland details
4. Diameter and thickness of the pipe
5. Material of construction
6. Slots/holes requirement on pipe
7. Spacing and size of these holes
8. Space between two pipe
9. Arrangement/Layout scheme for pipes

The sensor cable system shall permit the use of non-sensing jumper cable such that the Sensor Interface Modules may be installed in a convenient junction box or panel while the sensor cable is located at a remote location near the vessel or pipe system to be monitored. The maximum permissible offset between Sensor Interface Modules and sensor cable shall be no less than 1000m although offset distance of much less than 1000m will be more typical.

All jumper cable wiring shall be monitored for circuit integrity, continuity and damage by the same method as used for the sensor cable itself. Any breakage or loss of continuity in the jumper cable shall generate a CABLE BREAK or LOOP BREAK alarm at the Sensor Interface Module and in the control room.

The sensing cable should be UL Listed.

Capabilities of the Sensor Interface Module:

The Sensor Interface Modules shall provide the excitation voltage for the fuel probe or fuel sensor cable.

The Sensor Interface Module shall measure current flow to and from the sensor probe or sensor cable and use the information thus obtained to determine the status of the sensor, the presence of any leaked or spilled liquid hydrocarbons, the location of any spill or leak and the presence of any damage to the sensor or interconnecting wiring that would prevent the sensor from making a liquid hydrocarbon detection.

The Sensor Interface Module shall be a low voltage device with voltage requirement typically 12 Vdc, 24 Vdc or 24 Vac) and require less than 3 watts of total power to monitor up to 4 sensor probes and or up to 1000 meters of sensor cable. The 12 Vdc version shall be suitable for solar powered remote enclosures.

The output of the Senor Interface Modules shall be Modbus-RTU serial data delivered at an RS-485 two wire interface which would further be connected to FO converters for integration with the main control panel.

The Modbus data map shall be published by the system supplier such that 3rd party system integrators may access and utilize the data produced by the Sensor Interface Module for customized MMI display and event logging.

The Sensor Interface Module shall also provide data to the Vendor supplied alarm panel as discussed in the following section.

The Sensor Interface Modules shall provide power, status and communications LEDs visible for field personnel involved with system commissioning, testing or trouble shooting.

The Sensor Interface Modules shall be compact and suitable for mounting on 35 mm DIN rail and require less than 100 mm of rail space per device.

Capabilities of the Control Room Alarm Panel (Touch Screen Version):

The Control Room Alarm Panel (Touch Screen Version) shall be capable of monitoring up to 250 Sensor Interface Modules.

The Control Room Alarm Panel (Touch Screen Version) shall display the current status of all monitored Sensor Interface Modules including NORMAL, LEAK DETECTED, CABLE BREAK, LOOP BREAK, COMM ALARM, and other diagnostic conditions requiring operator attention. The primary display shall be a full color, high resolution, 12-inch (diagonal measurement) touchscreen.

The Control Room Alarm Panel (Touch Screen Version) shall be capable of indicating the location of any detected leak (probe or sensor cable) on a graphic background selected by the facility staff. The background image can be a plan view of the facility, an aerial photograph, the photograph of a particular piece of equipment or any other image that is meaningful to the local staff. When a leak is detected, a flashing icon shall be superimposed at the appropriate location on the background image.

The Control Room Alarm Panel (Touch Screen Version) shall log no less than the last 5000 events and each event record shall contain:

- Date and Time of Occurrence
- Channel Number of Sensor Interface Making the leak detection or trouble report
- Type of Alarm
- Location of Leak detection (applicable for sensor cable or multi-probe circuits)
- Sequential Number
- (note Alarm Acknowledgement and Reset shall be logged as a separate event)

Events shall be sortable by channel number and event type.

The Control Room Alarm Panel (Touch Screen Version) shall maintain a complete data base for all currently monitored Sensor Interface Modules and Event History. Access to this data base shall be via Modbus RTU or Modbus ASCII. Modus registers shall be made available through an RS232/RS485 (field selectable) serial data port at data rate of 9600, 19200 or 38400 Baud Rate. This data base shall be in addition to the locally maintained current status Modbus Registers maintained at the individual Sensor Interface Modules.

Full access to the Touch Screen shall be available for remote viewing via VNC server (installed at the touchscreen) and remote viewing VNC client installed on staff or supervisor laptop computers. Access to the Control Room Alarm Panel (Touch Screen Version) for remote viewing shall be made via a standard Ethernet LAN cable.

The Control Room Alarm Panel (Touch Screen Version) shall be capable of alerting up to 10 remote users via email to any detected alarm for LEAK, TROUBLE or SERVICE NEEDED.

The Control Room Alarm Panel (Touch Screen Version) shall use the built-in touch screen panel for channel selection, access to detailed status information, set-up menus, event history viewing, etc.

The Control Room Alarm Panel (Touch Screen Version) shall be suited for controlled environment installations. The area where the Control Room Alarm Panel is mounted shall be classified as non-hazardous, maximum ambient temperature of 60°C, minimum ambient temperature of -20°C with humidity ranging from 10% to 95% non-condensing.

The Control Room Alarm Panel (Touch Screen Version) shall consume no more than 30W at 24 Vac 50/60.

The Control Room Alarm Panel (Touch Screen Version) shall listed by UL listed, CE certified and FCC approved or equivalent.

Technical Features:

Other essential items, accessories, junction boxes, jumper cable, branch connectors, end terminations, leader cables shall be available from the supplier of the Liquid Hydrocarbon Detection System.

Liquid Hydrocarbon Detection System is required for continuous monitoring of leaked or spilled liquid hydrocarbons can occur from tanks, pipes, valves, pumps, and other fittings and containers and all components of the system shall be suitable for installation in airport premises.

Liquid Hydrocarbon Detection System shall detect petroleum based products such as naphtha, gasoline, jet fuel, diesel, fuel oil, crude oil and similar hydrocarbon fluids that remain in their liquid under ambient temperature and pressure. The system shall not detect water, salt water, condensation, mist, fog, snow melt or ground water. However layers of fuel or other hydrocarbon liquid floating on water shall be detected.

Sensor Interface Modules shall be powered by 12 VDC, 24 VDC, or 24 VAC; sensor probes and sensor cables shall be energized by the Sensor Interface Modules at intrinsically safe energy levels generally less than 65 VDC and current limited to less than 1 mA.

Sensor Probe Housing and Sensor Cable shall be suited for corrosive saline and high humidity environment.

All enclosures for electrical equipment shall be suitable for use in hazardous area as per facility hazardous area classification and Vendor shall submit valid test certificates issued by

CIMFR/PESOP. Flameproof enclosures which are manufactured outside India and certified by accredited international authorities shall also have approval of PESO, India.

Probe type liquid hydrocarbon detectors shall be SIL-2 certified from an accredited international certification agency.

No operational or start-up override switches are permissible.

All field mounted junction boxes or instrument enclosures shall be provided with a canopy or sunshade for protection against rain and intense solar radiation. Note that this requirement does not apply to the sensor probes or sensor cable itself, however in the case of the sensor cable a version specifically fabricated with built-in protection against high levels of solar radiation may be selected.

Although the Liquid Hydrocarbon Detection System may be interfaced directly to PLC/DCS control system at the Sensor Interface Module level, most installation will take advantage of a centrally located control room alarm panel. At no point in this specification is there any intention to prohibit or restrict the Liquid Hydrocarbon Detection System from utilizing a panel based, user interface providing that the system can be further interfaced to the facility PCL/DCS or SCADA monitoring system if desired.

Power Supply Requirements:

- For control room panels: owner may designate his choice of 120/230 Vac 50/60 hz or 24 Vac 50/60 Hz or 24 Vdc. Typical control room alarm panel load is 30W or less.
- For field installed sensor interface modules: owner may opt for 12 Vd c/ 24 Vdc or 24 Vac 50/60 Hz options. Note the 12 Vdc option is suitable for solar powered remote panels where applicable Typical field panel load is 2.5 W per Sensor Interface Module and an additional 5 w for each RTU radio installed or 5 watts for a Fiber Optic Modem if installed.

Where applicable AC to DC power supply units shall be provided for each cabinet. It shall be ensured that the power supply units are redundant and failure of one shall not affect the operation of any co-located PLC system.

Vendor shall also include miniature circuit breaker (MCB) for AC supply to each power supply units and sub distributions within the systems. Bidder shall ensure that isolation facilities are provided for DC sub-systems so that maintenance work can be taken up during operation stage without causing any disturbance to other sub-systems and devices.

Power distribution network shall be designed in such a way that a single point failure shall not cause tripping of the total system. Each distribution point shall be provided with a separate MCB of power rating for isolation of the system.

Irrespective of above, Bidder shall indicate the earthing philosophy of their offered systems including field devices and include their offer including provision for earthing lugs, earthing cable

etc. including final connectivity. Provisions of earth pits shall be under the owner's scope for which Bidder shall indicate the requirements.

Environmental Conditions for Sensor Elements:

- For fuel sensor probe
  - Operating Temperature Range -40°C to 85°C
  - Relative Humidity Range: No restriction

- For the fuel sensor cables:
  - Operating Temperature Range -20°C to 60°C
  - Relative Humidity Range: No restriction

Hazardous Area Classification for Sensor Elements:

- For fuel sensor probe
  - IS/ Class I Div 1 Groups A, B, C, D T4; Class I Zone 0 Ex iA IIC T4
  - NI/ Class I Div 2 Groups A, B, C, D T4; Class I Zone 0 Ex iA IIC T4
  - IEC 61508 safety Integrity Level -2

- For the fuel sensor cables:
  - Class I Div 1 Group A, B,C,D Zone 0 IIc when used in conjunction with Approved safety barrier.

Cabling Philosophy:

Cabling between Sensor Interface Modules and liquid hydrocarbon fuel detection sensor cable or fuel detection sensor probes shall be:

- 4 x 22 AWG (0.33 mm^2) or larger.
- Conductors shall be individually insulated with no less than 0.2 mm polyurethane , stranded copper, tin coated. Preferred color code for individual conductors shall be red, green, yellow, black.
- Outer jacket of cable shall be black matte finish, polyurethane, with overall diameter of 5.6 mm (+0.5 mm/ -0.5 mm).

This description / specification shall be considered to minimum conditions acceptable to operate the Liquid Hydrocarbon Leak Detection System as an intrinsically safe system in a hazardous area. Local facility regulations and standard wiring practices may supersede these requirements for heavy outer jacket, armor, etc. Conductor size of individual conductors may be increased to 0.85 mm^2.

Cabling between Sensor Interface Modules and Control Room Alarm Panel shall not exceed 1200 m without provision for additional amplification (or alternative telemetry methods such as wireless or fiber optic). Where twisted pair copper wire is used for telemetry between Sensor Interface Modules, RS-485 wiring standards shall be used. Generally, the RS-485 standards limit the maximum range to 1200m where wire size is 0.33 mm2 and baud rates are up to 115

kilo-baud. However, Vendor may make exceptions to the range limit when larger conductors are used and/or baud rate is reduced.

Power distribution wiring shall be determined by the installation site such that all field mounted Sensor Interface Modules, RTU radios (if installed) and Fiber Optic Modems (if installed) are supplied with no less than their required minimum operating voltage at the maximum electrical load condition. Power may be distributed from the control room, from remote power distribution panels or may be obtained via solar panels / storage batteries. The installer or project engineer shall perform a voltage drop calculation to assure that the power distribution system provides the required voltage and current at maximum load conditions.

Power distribution network shall be designed in such a way that single point failure shall not cause tripping of the total system. Each distribution point shall be provided with a separate MCB of power rating suitable for isolation of the system.

All above ground cable shall be laid in galvanized metallic cable trays. Underground cables shall be laid in armored HDPE conduits as per ASTM F2160.

All cables inside the control room shall be properly dressed and routed in GI perforated trays under false flooring which shall be supplied and installed by the Vendor. Trays shall have the capacity to lay the cable in a single layer with 20% spare capacity for future use. (Note that in retro-fit installation the power and telemetry cable associated with Liquid Hydrocarbon Leak Detection System may take advantage of existing spare capacity from other low voltage and telemetry system.) Telemetry pairs and operating power to remote Sensor Interface Module panels may share the same route and trays except where Intrinsic Safe wiring practices specifically prohibit co-routing of telemetry, power and IS circuits. In most cases, the cabling between the control room and the Sensor Interface module (both power distribution and telemetry) will not be intrinsically safe. However the cabling between the Sensor Interface Modules and the Hydrocarbon Sensor Cable or Probe, will be intrinsically safe and require the standard circuit segregation practices associated with IS wiring.

Junction boxes in hazardous areas shall be certified flameproof.

Junction boxes shall be weather proof to IP65/67.

Each JB shall be provided with at least two multi-core entries with all entries but one plugged with waterproof and flame proof plugs.

All cable glands shall be provided with PVC shrouds to prevent ingress of moisture and rainwater.

Junction boxes in the field as well as in control room shall be provided with sufficient number of terminals to terminate all pairs of multi-core cable and shield of individual pairs where applicable. Generally for cabling between control room and remote Sensor Interface Panels, there will be one pair for power distribution and one shielded pair for RS485 telemetry. Frequently both power and telemetry pair will be part of the same multi-pair cable. For cabling

between the Sensor Interface Modules and the sensor cable or sensor probe, there are typically four conductors arranged as an un-shielded quad.

Cable Glands:

All cable glands shall be double compression type, nickel-plated and weather proof and flame proof suitable for installation in an area classification of IEC Zone I Gas Group IIC. The cable glands shall be provided with PVC hood. Cable glands shall be suitable for the cable dimensions with a +/- 2 mm tolerance. The plugs and adaptors shall also be weather proof, flameproof, and suitable for installation in of IEC Zone I Gas Group IIC.

Audio-Visual Alarm:

Acoustic and visual alarms shall be automatically activated from the Liquid Hydrocarbon Leak Detection System Control Room Alarm Panel.

On receipt of a leak detection signal from Sensor Interface Modules, the control room panel shall sound, alarm, and indicate leak detection by means of a built-in buzzer, LED status lights and alphanumeric message. Depending on the noise level in the control room, many user may choose to supplement the built-in acoustic and visual indications with louder alarm buzzers and extra lights or beacons. The Vendor shall make such equipment available as part of the standard offering and control room alarm panels shall provide relays that actuate on leak detection with contact ratings suitable to operate such external horn and/or light-beacon.

Portable Sensor Monitoring Devices:

The Vendor shall make available, hand held, battery powered devices that may be directly connected to Liquid Hydro Carbon Leak Detection Cable or Liquid Hydrocarbon Leak Detection Probe on a temporary basis. Such hand held equipment, shall have the capability to report the status of the locally connected sensor, indicate the location of any detected leak and generally assist facility staff in the verification and localization of any reported leak detection. Hand held units shall be battery powered and be fitted with adapters as necessary to connect to any installed Liquid Hydrocarbon Leak Detection sensor.

Spares:

Bidder shall quote any required or recommended construction or commissioning spares and shall quote estimated operational spares for a minimum of 2 years or longer as the project manager shall require.

Special Tools:

Bidder shall quote any required or recommended special tools required for installation, commissioning, service and maintenance including hand held Portable Sensor Monitoring Devices as needed for installation, start-up and a minimum of 2 years operation (or longer as the project manager shall require.)

Vendor's Scope of Supply and Works

The Vendor shall be responsible for:

Supply of all components of the Liquid Hydrocarbon Leak Detection System including but not limited to all cable and probe type sensors, inter-connect signal, power and telemetry cabling, specialized slotted PVC conduit used for buried sensor cable, pull boxes, pull rope, specialized PVC conduit fittings, field panels for installation of Sensor Interface Modules which may include solar power systems, control room panels, junction boxes , radios, fiber optic modems, special tools, hand held test instruments, etc.

The Vendor shall additionally offer detailed engineering services to design and specific sensor placement, cabling, field panel placement, etc. Use of such engineering service shall be at the option of the project manager. Vendor shall offer a quote for engineering services at the time of tender.

The Vendor shall additionally offer installation and commissioning services or supervision thereof at the option of the project manager. Vendor shall offer a quote for installation and commissioning services or supervision thereof at the time of tender.

The Vendor shall offer complete preparation of drawings, documents, specifications, installation procedures, commission procedures, operation procedures, trouble shooting, repair and maintenance procedures, factory test certification and other documents as may be required by the project manager. Vendor shall offer a quote for documentation services at the time of tender.

The Vendor shall offer training of buyers personnel on commissioning procedure, operating procedure, trouble shooting and maintenance of the system including necessary steps to reset, or replace sensor cable and probes that have been exposed to leaked or spilled liquid hydrocarbons. Vendor shall offer a quote for training services at the time of tender.

Inspection, Testing and Commissioning:

Inspection Testing Plan

Vendor shall submit their own testing, installation, commissioning and acceptance procedures including purpose of test, test definition of input, procedure, results, expected and acceptance criteria. Such submittal shall be made to the project manager at a reasonable time after award of contract.

For software, submittal shall include software qualification reports current to the latest revision.

All normal quality control testing shall be conducted as per normal production process and Vendor shall make results of such production quality testing available to the buyer on request.

Vendor shall submit its Quality Manual or similar global document and copies of ISO 9001 certification.

Factory Acceptance Testing (FAT)

Vendor shall arrange to host a visit by the Owner's representative / Third Party Inspection (TPI) Agency selected by the owner. The expenses and fee charged by the representative or owner's agent shall be borne by the owner. The cost of performing the tests and expenses associated with hosting the inspectors visit (including staff time of the Vendor factory personnel) shall be borne by the Vendor.

Vendor shall propose a procedure for the FAT visit within a reasonable time after award of contract and sufficiently in advance of any scheduled visit to allow for procedure review by the owner.

During the FAT visit the Vendor shall make all materials for available visual inspection. A representative sub-set of equipment and sensor may be temporarily assembled into a working system to demonstrate operation if requested in advance of the visit. Typically, the FAT inspector will sight and count boxed sensors and equipment and open a small random sample. A representative probe type senor may be exposed to liquid hydrocarbon if requested, but due to the one-use nature of the cable type sensors, QC records are used in lieu of wet testing.

No material or equipment shall be transported until all required tests have been successfully complete and the material/equipment have been certified "Ready for Shipment" by the Owner /TPI. Such certification shall be supplied within 3 working days of a successful inspection.

Vendor shall notify owner of planned readiness for inspection at least 2 weeks prior to preferred FAT date.

Owner/TPI shall have the right to request additional tests or procedures beyond those outlined in the agreed procedure (section 7.2.2), however materials consumed for additional testing and staff time in excess of the planned visit day, will be reimbursed by the owner at the prevailing rate for engineering services and cost of products consumed.

Owner shall have the right to waive FAT inspection in its entirety or inspect a representative shipment in large projects involving multiple releases.

Installation, Testing and Commissioning:

Vendor shall install and commission the components of the Liquid Hydrocarbon Leak Detection System or supervise the performance thereof if contracted to do so.

Before installation or commissioning, Vendor and project manager will thoroughly check all equipment for completeness and "ready for installation" site conditions.

For projects involving coordination of multiple trades or contractors the project manager shall be responsible for coordination and scheduling of work that must be complete prior to installation and/or commission of the Liquid Hydrocarbon Leak Detection System. The owner/project manager shall be responsible for costs associated with premature mobilization of the Liquid Hydrocarbon Leak Detection System Vendor. If the necessary site work has not been completed or essential elements such as power distribution , fiber optic cable by others, has not

been completed when the Liquid Hydrocarbon Leak Detection System Vendor is requested to be on site, then the owner shall be responsible for time and expenses associated with keeping the Vendor's crew on standby.

Site Acceptance Testing:

Owner shall provisionally take over the system after satisfactory completion of functional performance testing. System acceptance testing shall commence on the completion of the entire system or designated sub-systems should the owner so desire.

Functional testing shall include:

- Verification of hardware as per Bill of Material
- Visual and mechanical check of workmanship, identification, ferruling, nameplates, etc.
- System configuration as per approved set-up documents
- Demonstration of diagnostics
- Simulation of leak events using "pinch test" for cable type sensors and naphtha dip test for probe type sensors
- Verification that a system map has been prepared and posted (draft form is acceptable if final version is still in preparation.

Any necessary replacement of failed equipment shall be made by the Vendor if defect is determined to be caused by faulty materials or factory workmanship.

Any necessary corrections to installation, equipment damage due to improper installation shall be corrected or replaced by the party responsible for the installation which may be the system Vendor or an installer under contract to the owner.

Any failure during Site Acceptance Testing shall be deemed a failure for the sub-system under test and a complete test for the impacted sub-system shall be repeated from the beginning. A failure in one sub-system shall not constitute grounds for repeating the Site Acceptance Testing for all sub-systems unless there is reasonable cause to link failure modes across more than one sub-system.

Upon completion of satisfactory Site Acceptance Testing, the owner or his representative shall provide written acceptance of the system as being in compliance with the design and delivered in working order.

Final Acceptance Testing:

Owner will take over the system from the Vendor after trouble free uninterrupted operation of the complete system for 15 days from the date of completion of the Site Acceptance Test. (Note detection of a Liquid Hydrocarbon Leak during this 15 day period shall not constitute grounds for non-acceptance).

Final Acceptance Testing shall start over at day one if the 15 day period is interrupted by a system failure.

The warranty period will commence at the completion of the Final Acceptance Test

Training:

Vendor shall impart training to the site personnel for theory, routine operation, preventive maintenance, trouble shooting and leak response for the Liquid Hydrocarbon Leak Detection System.

The training shall be imparted at the owner's site for a minimum of two days immediately after the commissioning and may be scheduled to coincide with the Site Acceptance Testing. Owner may designate up t0 15 people to receive such training and shall make space and facilities available for the training.

The Vendor shall quote the cost for the above basic training and any additional training requested by the owner at the time of tender.

Owner may choose to waive training if similar equipment manufactured by the same Vendor is already installed and being maintained by plant personnel

Warranty:

Vendor shall offer a parts replacement warranty for any defects arising from material failure or factory workmanship.

Vendor shall not be held responsible for the cost associated with removal or replacement of failed equipment, cost to return equipment to the Vendor factory for evaluation or consequential damages or business disruption attributed to failure of the equipment.

The period of the limited warranty shall be:

a) 24 months from the date of shipment or 18 months from the date of Final Acceptance Test (whichever occurs first)

b) An extended 60 month warranty from date of Final Acceptance Test shall be made available for additional 15% premium on the cost of purchase parts.

Vendor shall maintain a reasonable inventory of spare parts in country or at a suitable location such that replacement parts can be provided to the site within 2 weeks of notification of part failure from the owner.

Post Warranty Maintenance:

The Vendor/Bidder shall submit annual post-warranty maintenance proposal at the time of the bid which shall be as follows:

a) The proposal shall include separate price items and at the owners' request, the Vendor shall provide comprehensive maintenance including supply of spares including supply of spares for the period of three years after the expiry of the warranty period.

b) The travel, boarding, and lodging of service engineer/technician shall be borne by the Vendor (but included in the overall cost of the maintenance proposal).

c) The Vendor shall provide their own tools and equipment necessary for maintenance of the system

d) The proposal shall include cost and provision for:

Preventive Maintenance on an annual basis including verification of end-to-end alarm performance via a naphtha wet test for sensor probes and a “pinch” test for sensor cables on a representative random sample of alarm circuit

Emergency Maintenance in the event of malfunction of the system shall provide for an experienced service engineer to be available at the site within one week of the receipt of such request from the owner.

e) Note that detection of a leak, and a response there to does not constitute a need for either Preventive Maintenance or Emergency Maintenance although the owner and Vendor may negotiate a charge for Vendor support to assist the site in restoring the Liquid Hydrocarbon Leak Detection System to full operation after a leak incident has occurred.

Delivery, Storage, Safety and Handling:

All components of the Liquid Hydrocarbon Leak Detection System shall be shipped to the job-site in original manufacturers shipping containers. The storage, safety and handling of system components shall be conducted in accordance with the Vendor’s instructions. The owner shall be responsible for loss or damage to goods if the goods are stored in owner supplied facilities. Special terms must be negotiated at the time of tender if the owner wishes to Vendor to maintain and be accountable for materials after they are made available to the owner but are to be held on site pending installation.

1	Principle of Operation	To detect hydrocarbon liquids floating on water, spreading on flat surface, dripping from an above ground pipe or spreading in the sub-face backfill alongside a buried pipe, valve or fitting or beneath a storage tank
2	System Configuration	Detection system shall be comprised of field sensors directly connected to Senor Interface Modules which in turn are connected to a control room master alarm panel via direct connections or via wireless rf or fiber optic cabling. The system shall be used for early detection of leaking hydrocarbons for monitoring purposes (on/off action) and to provide audio-visual signal for operator’s alert. The system shall have the following features: • Sensor Interface Modules shall be as a minimum able to monitor 4 fuel detection probes or up to 1 km of fuel sensor cable

		• The control room panel shall have the capability to monitor up to 128 Sensor Interface Modules (512 probes or up to 128 km of sensor cable) • The control room panels (touch screen version) shall have the capability to monitor up to 250 Sensor Interface Modules (1000 probes or 250 km of sensor cable • The control room panels shall have RS232/RS485 Modbus RTU connectivity to DCS/PLC/PC based monitoring system • Touch Screen version shall allow for email alarm notification and remote viewing via VNC • All necessary safety barriers shall be included to ensure intrinsic safe operation of the probes and sensor cable in hazardous areas but the control instruments shall generally be located in a safe/ordinary area
3	Field Sensor	• Shall be based on change in resistance of a carbon enriched polymer • Probe type shall have a minimum 100 mm of exposed sensor surface encased in a polypropylene tube with anti-static additive. • Cable type shall have up to 1 km of fuel sensitive surface at which any point along the length of cable shall be capable of detecting liquid hydrocarbons • All associated connections, cabling, and fittings shall be fuel resistant.-
4	Response time of probe type sensors	Shall be 5 seconds or less for naphtha, gasoline, jet fuel and diesel. Longer times are acceptable for crude oil and heavy fuel oils
4 a	Response time for cable type sensor	Shall vary depending on volatility of spilled hydrocarbons and ambient temperature
5	Sensor Life	3 to 5 years of continuous outdoor operation
6	Sensor checking – probe type	Will generate immediate alarm when tip of sensor is immersed in naphtha. Alarm condition will reset in the air within 4 hours
6a	Sensor checking –cable type	End to end system alarm and leak locating function to be generated by bending the sensor cable over a short radius and holding in position for 30 seconds. Alarm conditions to return to normal when cable is returned to unbent conditions
7	Master Control	• Able to detect condition of any probes or cable type sensor and provide audio-visual annunciation of leak detection, leak location and any condition requiring maintenance attention • It shall have the following minimum features:

		• Capable of monitoring up to 512 probes (1000 for touch screen version • Capable of monitoring up to 128 km od sensor cable (250 km for touch screen version) • Fully microprocessor based system having 4 x 20 character LCD display panel or 12" full color touch screen (Touch Screen version only) • Dedicated LED status lights on non-touchscreen version for LEAK, TROUBLE or SERVICE NEEDED • Event logging for last 2048 events (non-touch screen) or 5000 events (touch screen version) • Continuous self- test for system faults or communication failures • Serial data port (RS232 or RS485) for Modbus RTU uplink to host DCS/PLC or PC based control system • RS-485 serial port for communication with Sensor Interface Modules in local or remote panels • Relay contacts with (DPDT 5A at 230 VAC or 24 VDC) for LEAK, TROUBLE or SERVICE NEEDED in non-touch screen version • User programmable relays in expandable modules of 8 or 32 relays for touch screen version • All power supplies, safety barriers, firmware as needed for alarm functions and communications and alarm/ status and leak location display
8	Cables	No changes needed
9	Power Supply	Control Room Panels shall be operable at 120/230 Vac 50/60 Hz. Power for control room shall be at one point per panel Field panels shall operate at 12VDC, 24 VDC or 24 VAC as circumstances warrant. Power shall be distributed from the control room where economically feasible but may be supplied from field power connections if available. Solar power option for field panels shall be available for remote sites. Power distribution networks shall be designed in such a way that single point failure shall not case tripping of the total system. Each distribution pint shall be provided with a separate MCB of power rating suitable for isolation of the sub-system

10	Approvals for sensors	Class 1 Div 1 Group A, B, C, D and/or Zone 1 Group IIC or better. Temperature Class T4 When installed with suitable safety barrier as specified by Vendor
11	Approvals	No changes except add this note: Safety approval ratings for all sensor cable and probes are contingent on installation of suitable safety barrier as specified by the Vendor
12	Operating Temperature	Probe Type Sensors: -40°C to 85°C Cable Type Sensors: -20°C to 60°C Sensor Interface Modules: 0°C to 50°C Control Room Alarm Panel (non-touch screen): 0°C to 50°C Control Room Alarm Panel (touch screen type): -20°C to 60°C
13	Humidity	5% to 95% non-condensing
14	Safety Integrity Level	SIL 2 for probe type sensors certified by TUV/EXIDA or other internationally accredited agency
15	Dimensions and weight	Varies and will be provided by Vendor
16	Accessories Required	No change
17	Factory Acceptance Testing	Change last sentence to read: Third Party Inspection shall be hosted by the Vendor at no cost to the owner up to two days. TPI travel expenses and inspection fee shall be borne by the owner
18	Quantity Required	Varied by BoM
19	Warranty	24 months from date of shipment 18 months from date of Final Acceptance Test 5 years from date of FAT available at 15% premium based on cost of materials