An advanced safety proactive method to enhance jet fire prevention, mitigation and control

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THE JET FIRE PHENOMENA

The jet fire or “spray fire” phenomena represent a significant element of the risk associated with major accidents in the Energy and Oil & Gas Market.

Jet fire is a turbulent diffusion flame resulting from the combustion of a fuel continuously released with some significant momentum in a particular direction or directions.

Jet fires can arise from releases of gaseous, in case of flashing liquid (two phase) and pure liquid inventories the phenomena is called “flash fire”.

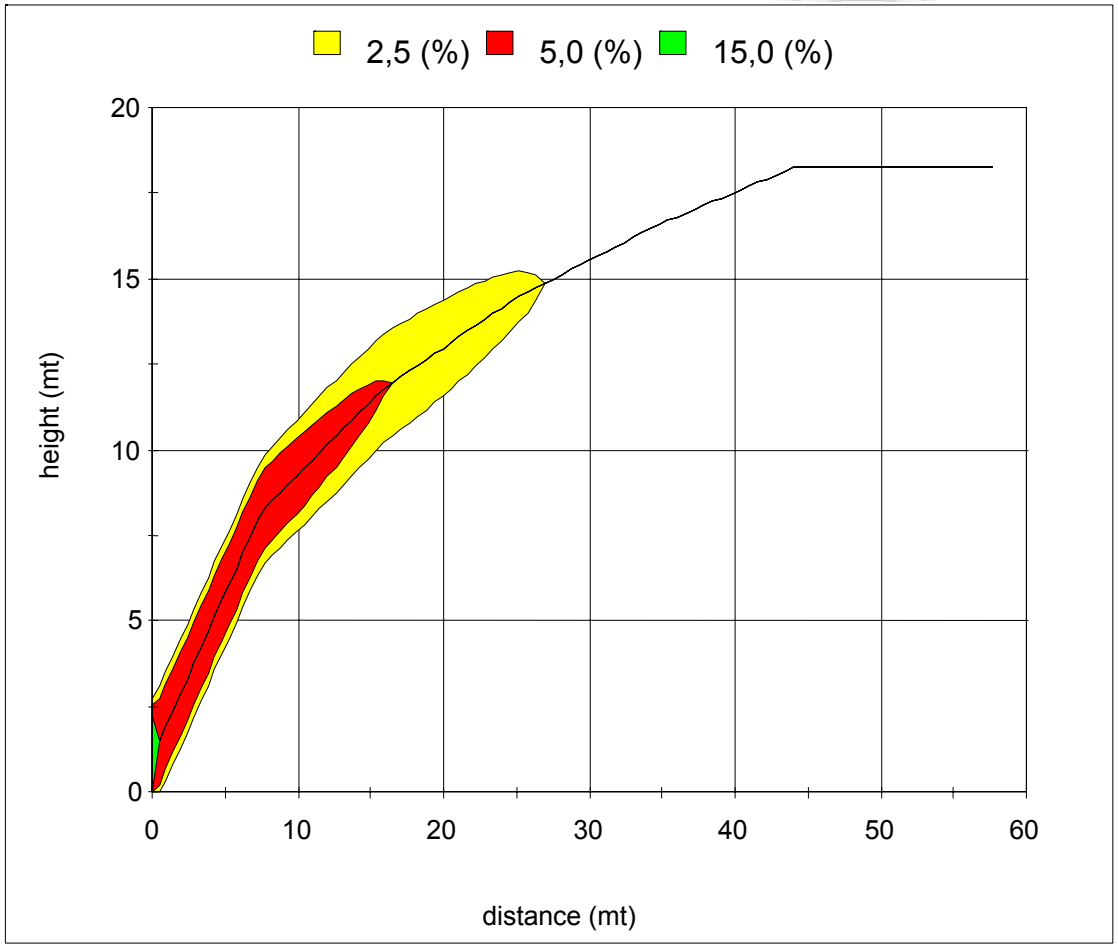
The jet fire is a effect of a leakage ignited from a pressurized equipment like flanges, cracked pipe work or vessel, fittings damaged, and generating high heat fluxes over 300 kW/m2 , flame temperature of 1350 º C, according different sources (HSE, SINTEF, etc.), with irreversible and domino effect on structures attacked by the jet fire.

It is assumed that personnel are able to survive and escape from exposure to heat fluxes less than 5 kW m-2, but fatality is assumed for higher heat flux values.

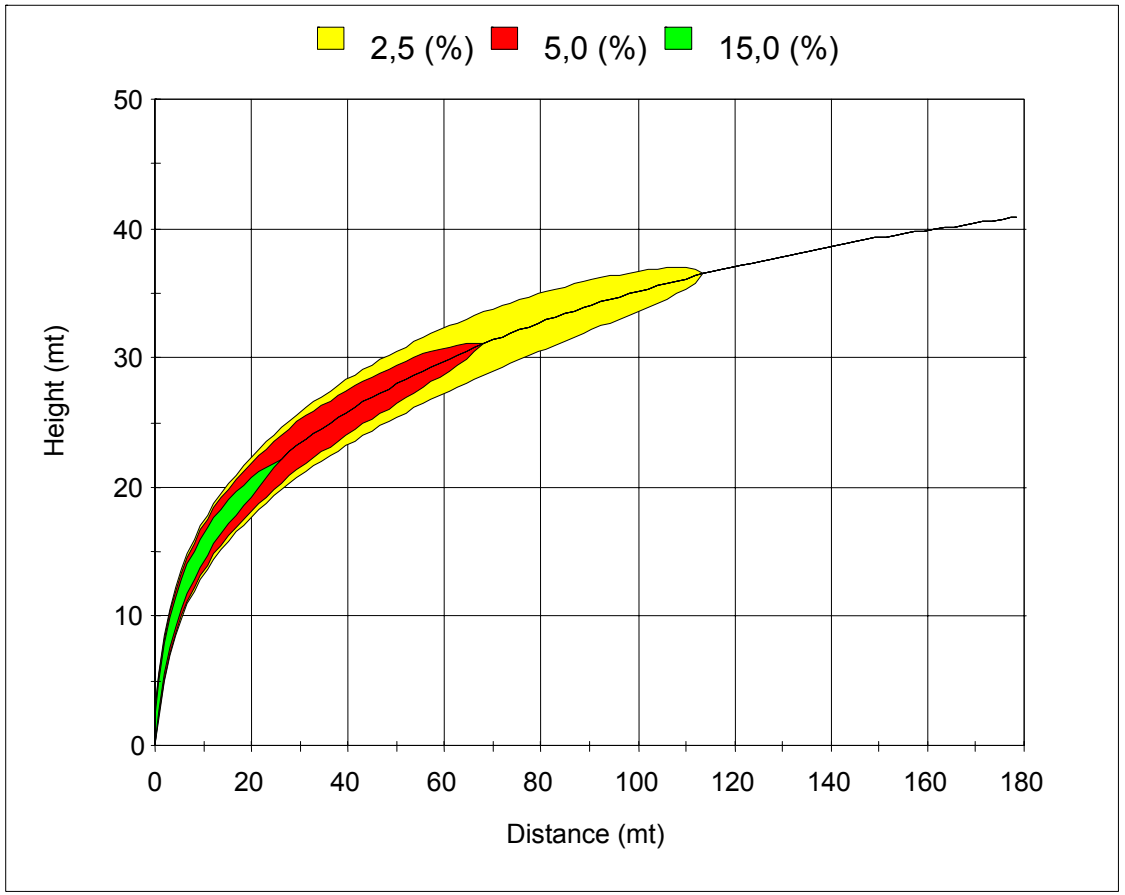
The properties of jet fires depend on the fuel composition, release conditions, release rate, release geometry, direction and ambient wind conditions.

Low velocity two-phase releases of condensate material can produce lazy, wind affected buoyant, sooty and highly radioactive flames similar to pool fires.

Sonic releases of natural gas can produce relatively high velocity fires that are much less buoyant, less sooty and hence less radioactive.



Leakage Sample 1: Natural gas release DN100 - 0,5 barg - 20 °C Meteo: wind 5 m/s
Gas density is lower than the atmosphere and it is venting free.



Leakage Sample 2: Natural gas release DN100 - 0,5 barg - 20 °C Meteo: wind 2 m/s

Less wind speed means a lower dispersion and dilution with higher concentration till long distance from the emission point

MOST FREQUENT LEAKAGE CAUSES

Wrong or inaccurate project design

Equipment fault, corrosion (internal – external), mechanical stress (fatigue or wear), erosion, material defect

Bad operation or lack of maintenance

Bad or lack of procedure

IGNITION CAUSES

Hot works in the area of leakage

Electrical (sparks – bad contacts)

Hot draining or surfaces

Sparks generated by moving parts

Temporary or spot energy sources like ultrasounds, radio waves etc.

Temporary works or activity like drilling, plat start or shutdown, piping cleaning or blowing, erections, maintenance.

INDUSTRY PRACTICE

Specific recommendation, in design stage, according to standard and rules (ASME, ANSI/ISA, API, REMI, UNI, PED), about components sizing calculation, specific quality material control, factory test, site test.

Use of relief valves, PSV, flame arresters, LPS - Lightning Protection System , emergency depressurization, inserting systems, seamless piping, welding certification and inspecting, segregation, holding areas, maintenance procedure.

Static pressure test, leak detection pig, pipeline patrolling.

ACTIVE METHODS

The most common active methods are based on networks of gas leakage detection, mainly with electrochemical cells, infra-red (IR), laser in point spot or open path configuration.

The sensors are able to detect leakage and alert according to a specific Explosion Level related to the flammable of the combustible (see standard ANSI/ISA S12-13).

An analysis of 8 years of data relating to hydrocarbon releases (HSE, 1999b) indicates that across all installations and detection systems an effective detection rate of about 60% has been recorded.

Industry practice is based on the general guidance provided in the UK Offshore Operators Association guidelines, (UKOOA, 1995) , ISO and company rules and guidance it try to respond effectively and reliably to the hazard and to be tolerant of the environment and working procedures.

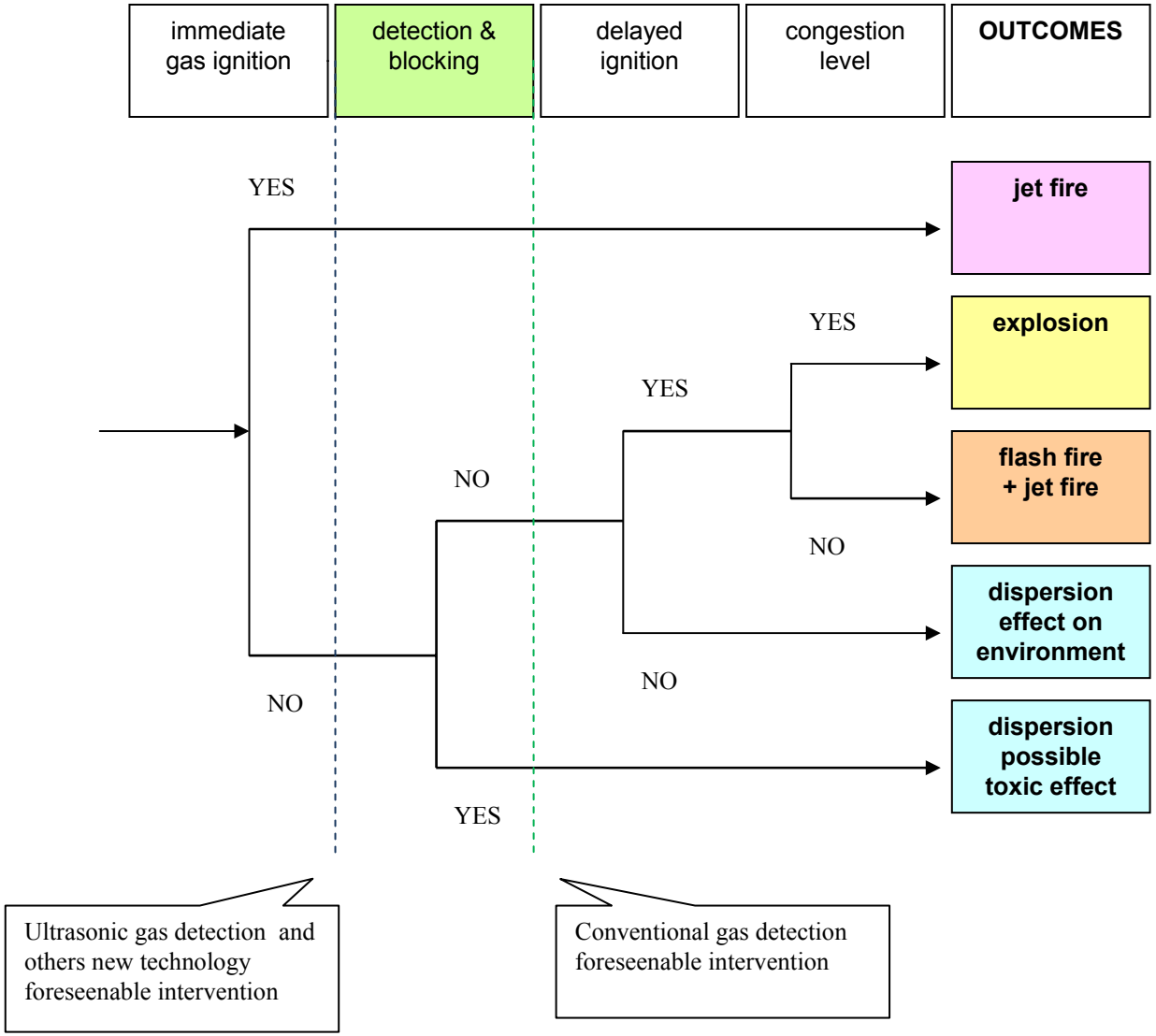
The areas of uncertainty are governed by the size and geometry of the area (confinement and congestion), ventilation and the nature of the release.

New systems based on acoustic monitoring , noises over 20.000 Hz called ultrasound technology, relation of measurement parameters of acoustic (dB) to flammable hazard in not well defined as well acoustic reflections and others noises may produce false alarms but mixing acoustic monitoring with gas sensors can increase the detection coverage.

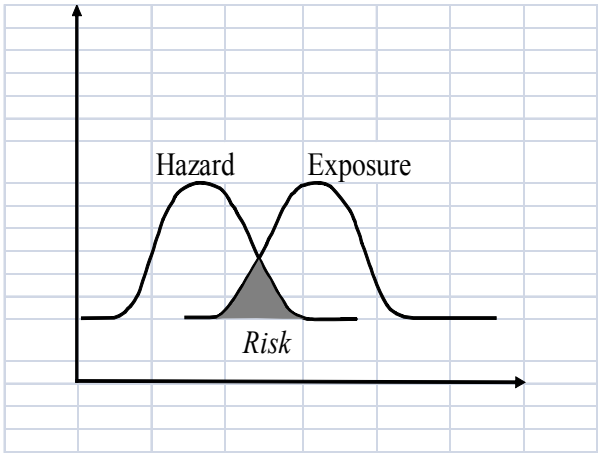
Hydrocarbon-sensing cables and hydrocarbon-permeable tube (sniffer tube) can be laid in close proximity along the pipeline with goods results for small leakage but only in short lines.

Low pressure/change in pressure measurements are sensitive only in major leak.

Dynamic simulation models are expensive and with long response time.


immediate gas ignition
detection & blocking
delayed ignition
congestion level
OUTCOMES
YES
jet fire
YES
explosion
YES
flash fire + jet fire
NO
NO
dispersion effect on environment
NO
dispersion possible toxic effect
NO
YES
Ultrasonic gas detection and others new technology foreseenable intervention
Conventional gas detection foreseenable intervention

Still a large portion of exposure is under risk of hazard.



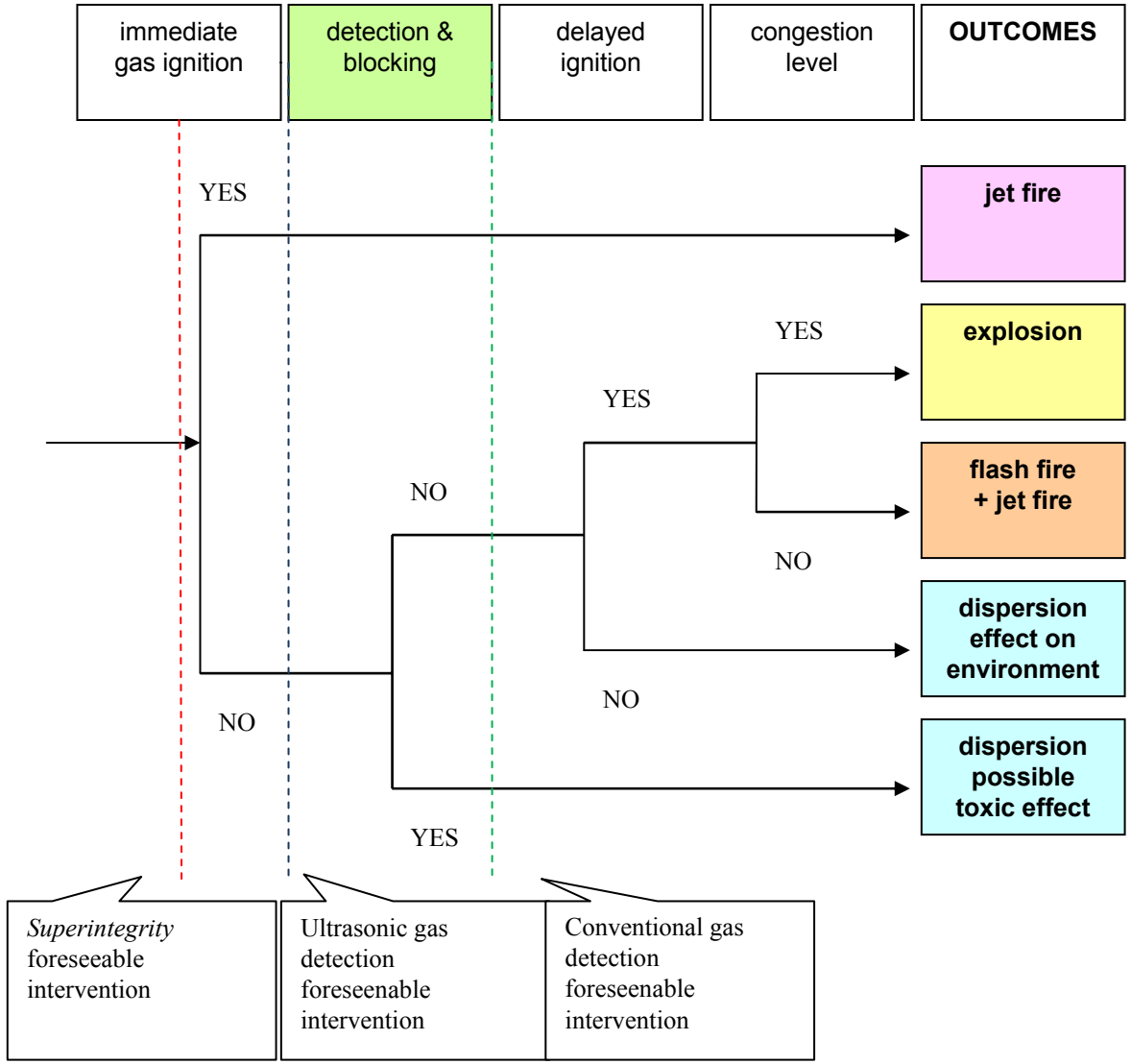
We don’t want proof the theorem where events or measured quantities that may either be single occurrences or evolve over time in an apparently random fashion when they occur to you the 1 to 100% probability is very likely to become 100%

We are proposing and innovative method, called by us *Superintegrity,* and adopted in plants since 2006 based on flow metering mathematic calculation designed in order to estimate in real time the values deemed useful to prevent jet fire on the line which has to be secured.

This method integrated with direct gas leakage detection may increase the efficiency and avoid false alarms with consequently plant unavailability.

The implementation of this method, which can be tailored as hardware-independent (for a basic coverage) and dedicated (for an extended coverage), to the specific needs of the plant, takes place by following a specific quality check.

Thanks to it, the End User can benefit from valuable advantages in plant loss prevention, health and environmental plant protection compliance programme, and savings on insurance coverage expenses.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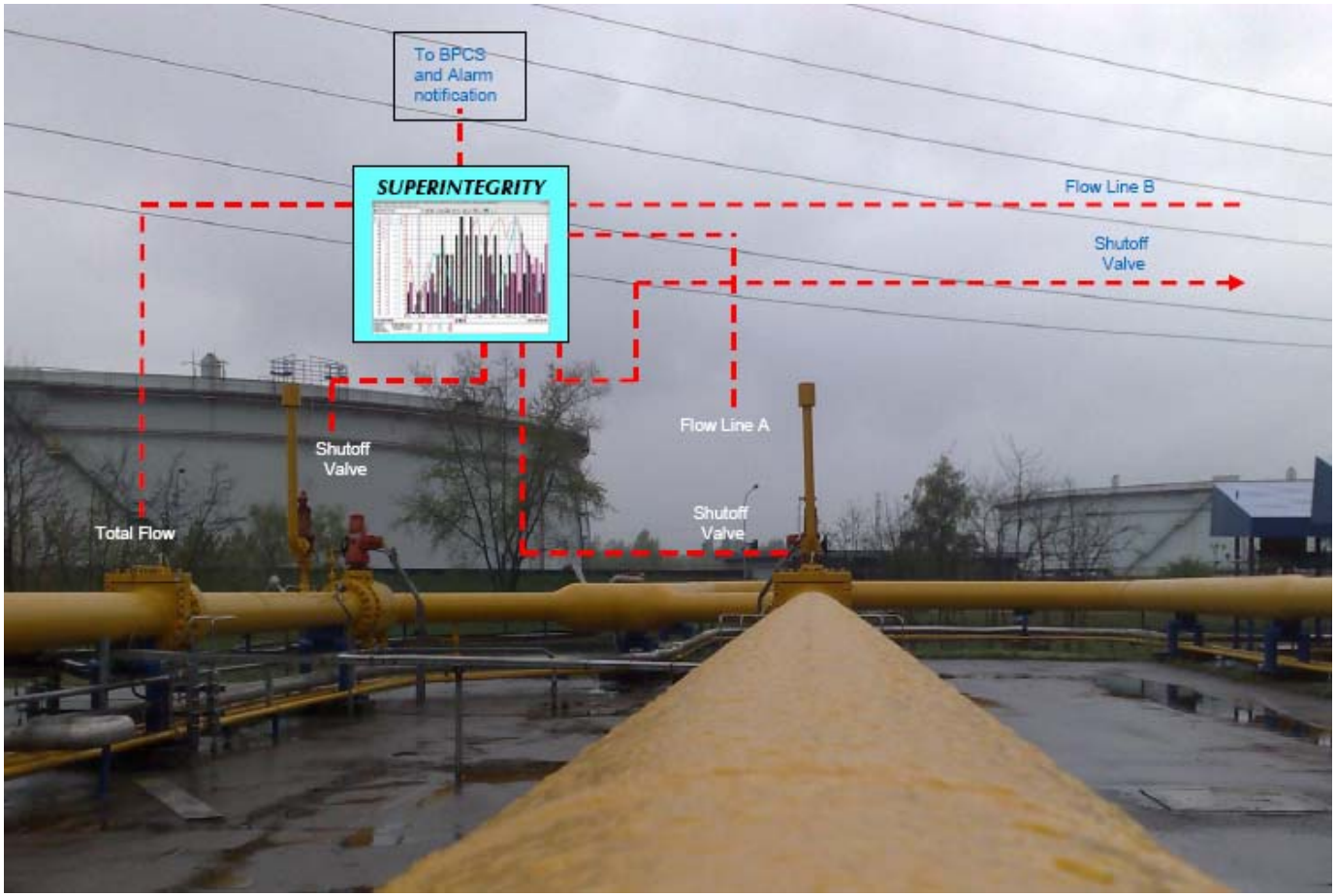
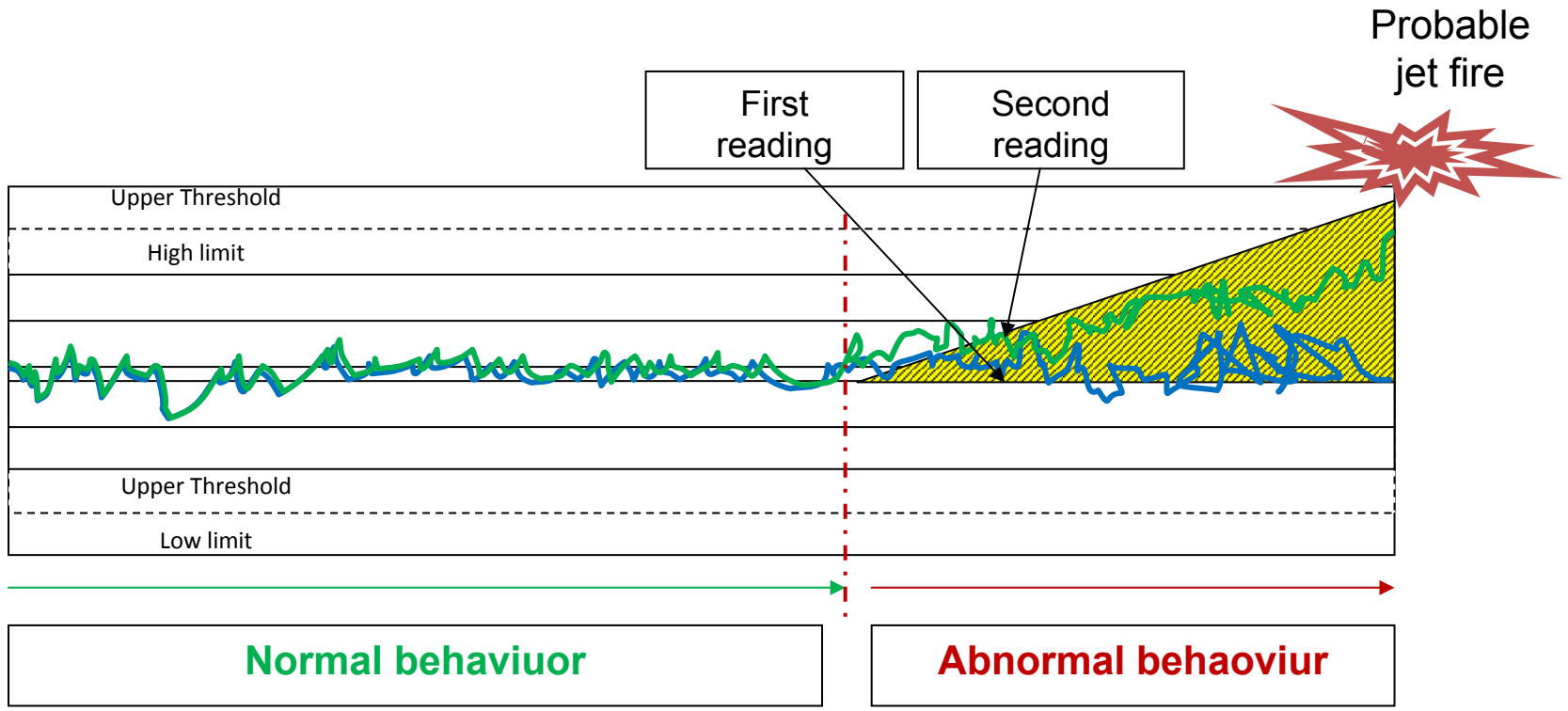
The method is based on a comparison of the corrected integrated flow rates (volumes and mass) that entered and left the pipeline over various segments and time periods.





Residual = Second reading – First reading

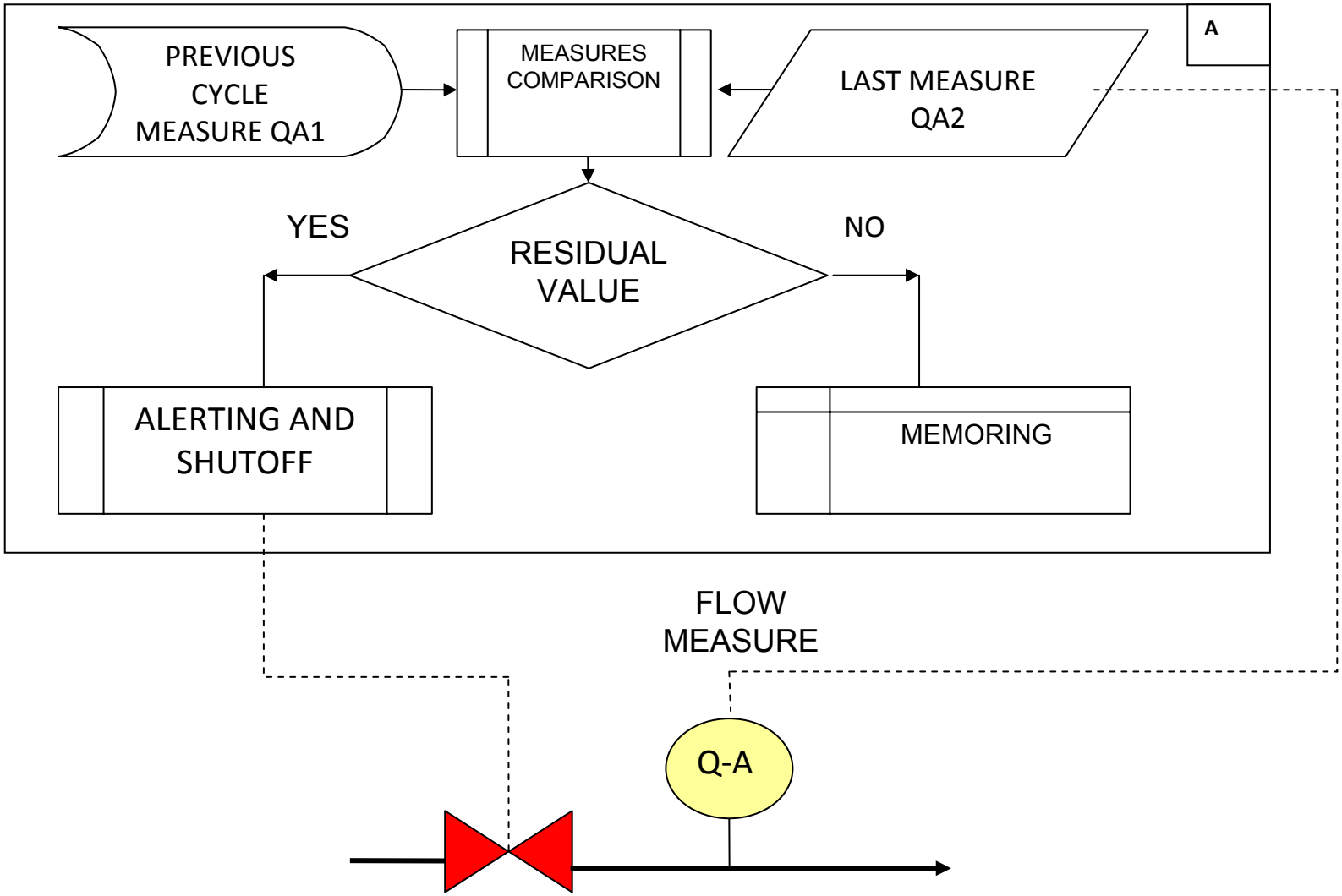
Alert for abnormal behaviour is initiated by the residual value

A continuous comparison between the data recorded by each single flow meter is also integrated by a continuous comparison between the data read and recorded in the previous cycle. The difference or better the residual is detected as an abnormal condition if out of the thresholds and a probable Jet Fire.

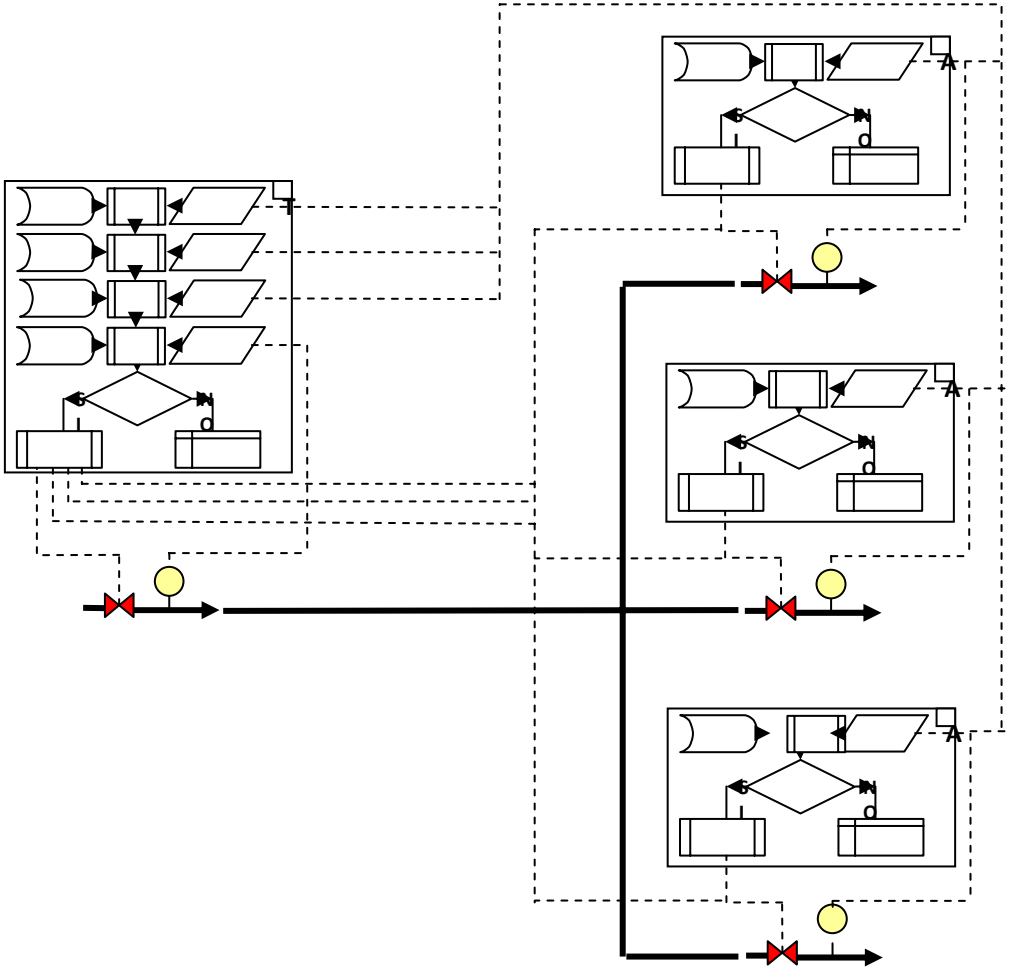
This relationship is resumed below:

$$QT(QT2-QT1) - (QA2-QA1) - (QB2-QB1) - (QC2-QC1) - (Qn2-Qn1) \neq 0$$

SINGLE ELEMENT MEASURING & CONTROL POINT



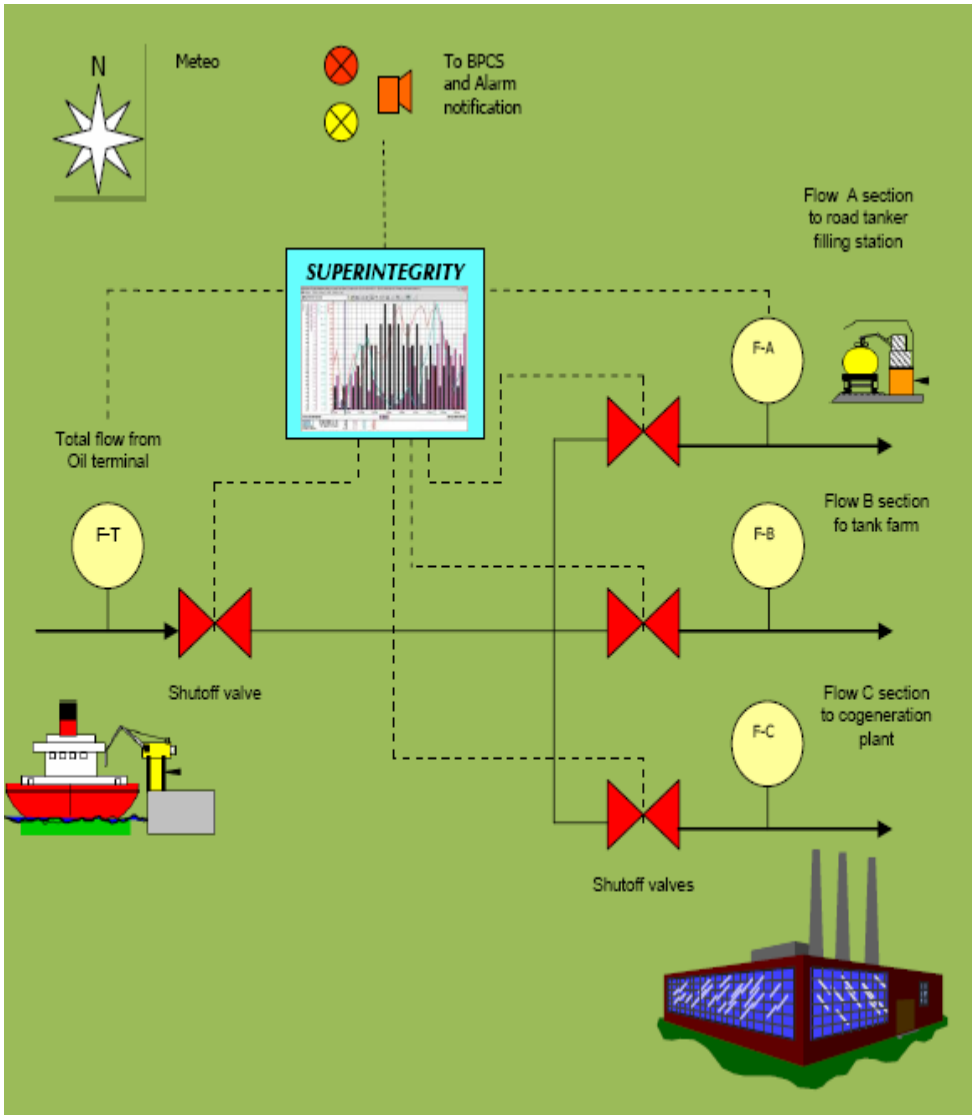
OVERALL PROTECTED PIPELINES LOGIC



Superintegrity complies with the following recommendations:

-API RP 1130
"Computational Pipeline Monitoring For Liquid Pipelines"

-IEC 61511
"Safety Instrumented Systems"



Criteria	Evaluation/Comments
Applicability & Availability	SUPEROFFICINA®-*Superintegrity* is commercially available and has been used on natural gas and crude oil transmission pipelines.
Effectiveness	*Sensivity* SUPEROFFICINA®-*Superintegrity* ***basic version,*** leak detection sensivity is directly affected by the data sampling capability of the SCADA system. Performance also depends on instruments quality and controller proficiency. SUPEROFFICINA®-*Superintegrity* ***extended version, d***etection times is typically 15 seconds to 1 minute depending upon the speed of data communication scan rate and computational time. *Accuracy* SUPEROFFICINA®-*Superintegrity*, largely relies on the accuracy of pipeline instrumentation to estimate parameters such as leak flow rate and volume lost.

Effectiveness	*Reliability* *Superintegrity* ***basic version,*** is continuously comparing the values recorded according the parameters setting in order to avoid false alarms. *superintegrity* ***extended version*** moreover is based on high-quality and SIL 2 equipments with a GPS synchronization. *Robustness* All mass balance systems are limited by the performance of the field meters. Some meters deal with transients better than others, *Superintegrity* is immune by transients and by poor meter maintenance or improper proving. However, as with any computer-based system it is not immune to failure and consistent operation and performance is dependent upon data communication links, power supply and periodic maintenance. SUPEROFFICINA® has developed a specific quality assurance plan installation and maintenance of *Superintegrity* in order to avoid failures.

Transferability & Feasibility	*Superintegrity* is reportedly transferable to natural gas and transferable to crude oil transmission lines and has the following benefits: ▪it can compensate for line packing and unpacking; ▪it can monitor bidirectional pipelines; ▪it is capable of monitoring relatively long pipeline segments (25 miles or more); ▪the *basic version* can be applied to systems in any environment; ▪the *extended version* use equipment that works the best under the extreme climatic conditions of Arctic or Alps. ▪the *basic version* does not require shutdown of operations for installation, calibration or maintenance; ▪the *basic version* is not effected by corrosive or abrasive liquids; ▪it permits application to pipelines which are “pigged”; ▪for leak detection redundancy, it is readily compatible with gas detection systems; and ▪it can reportedly detect leaks on natural gas transmission lines of less than 1% of flow. *Superintegrity,* perform best when: ▪The flow rate is highly variable; and ▪Large transients occur frequently.

Compatibility & System Requirements	*Instrumentation* *Superintegrity* ***basic version,*** operates using any high-quality electronic pressure transmitter, flow meter, or temperature normally used in the Energy and Oil & Gas industry. These instruments share a similar range of accuracy and repeatability that is suitable for leak detection. *Superintegrity* ***extended version*** operates using any high-quality and SIL 2 electronic pressure transmitter, flow meter, temperature and actuators normally used in the Energy and Oil Gas Industry. *Operating System/Communication* *Superintegrity* ***basic version***, relies solely on the data collected by the pipeline's SCADA or BPCS; therefore, it is imperative that the system is properly instrumented, calibrated, serviced and maintained. *Superintegrity* ***basic version*** software installation should be done as a specific application task (or multiple of it) directly on SCADA/BPCS or confined to a dedicated workstation that only communicates (via OPC, DDE, ODBC, ASCII, CSV or proprietary PLC/DDC even remotely via web client configuration), with the computer handling the pipeline data collected in real time.

Compatibility & System Requirements	*Superintegrity* ***extended version***, is pipeline SCADA/BPCS independent , designed as SIS (IEC 61511), connected to a dedicated front end system for data collection/exchange/ reporting and HMI features. ***Sampling Frequency*** *Superintegrity* ***basic version***, recommend that the SCADA system have the ability to scan or poll every second at least to ensure accurate leak location. *Superintegrity* ***extended version*** is capable of sampling the instruments in milliseconds interval times. ***Controller Training*** *Superintegrity* in both versions can be installed and tuned in approximately two weeks. An additional week is required to train engineering personnel and pipeline controllers.

Environmental Impacts	There are no air, land, water, energy, or other system requirements that may offset the anticipated environmental benefits of *Superintegrity*.
Regional Considerations	*Superintegrity* ***basic version*** is software based LDS that works in conjunction with instrumentation and SCADA or BPCS supplied by vendors others than SUPEROFFICINA®. It is installed on a computer in the control room; therefore, *Superintegrity* ***basic version*** can be applied to systems in any environment. *Superintegrity* ***extended version***, use equipment that works the best under the extreme climatic conditions of Arctic or Alps.

Field Performance	Few field test results are available for mass balance system since performance is directly related to the accuracy of the instrumentation (i.e., the better the instrumentation, the better the leak detection performance). The results of test conducted on SUPEROFFICINA®-*Superintegrity* is presented in the following table: **Scenario 1** Gathering to Power Plant – Natural Gas **Diameter** **Length** **Detected Leak** 10-6 in. 1 mile 1% of flow in < 1 min **Scenario 2** Gathering to Power Plant - Natural Gas **Diameter** **Length** **Detected Leak** 8 in. 1 mile 1% of flow in < 1 min **Scenario 3** Pumping Station to Tank Farm - Crude Oil **Diameter** **Length** **Detected Leak** 42 in. 20 mile 1% of flow in ⩽ 1 min

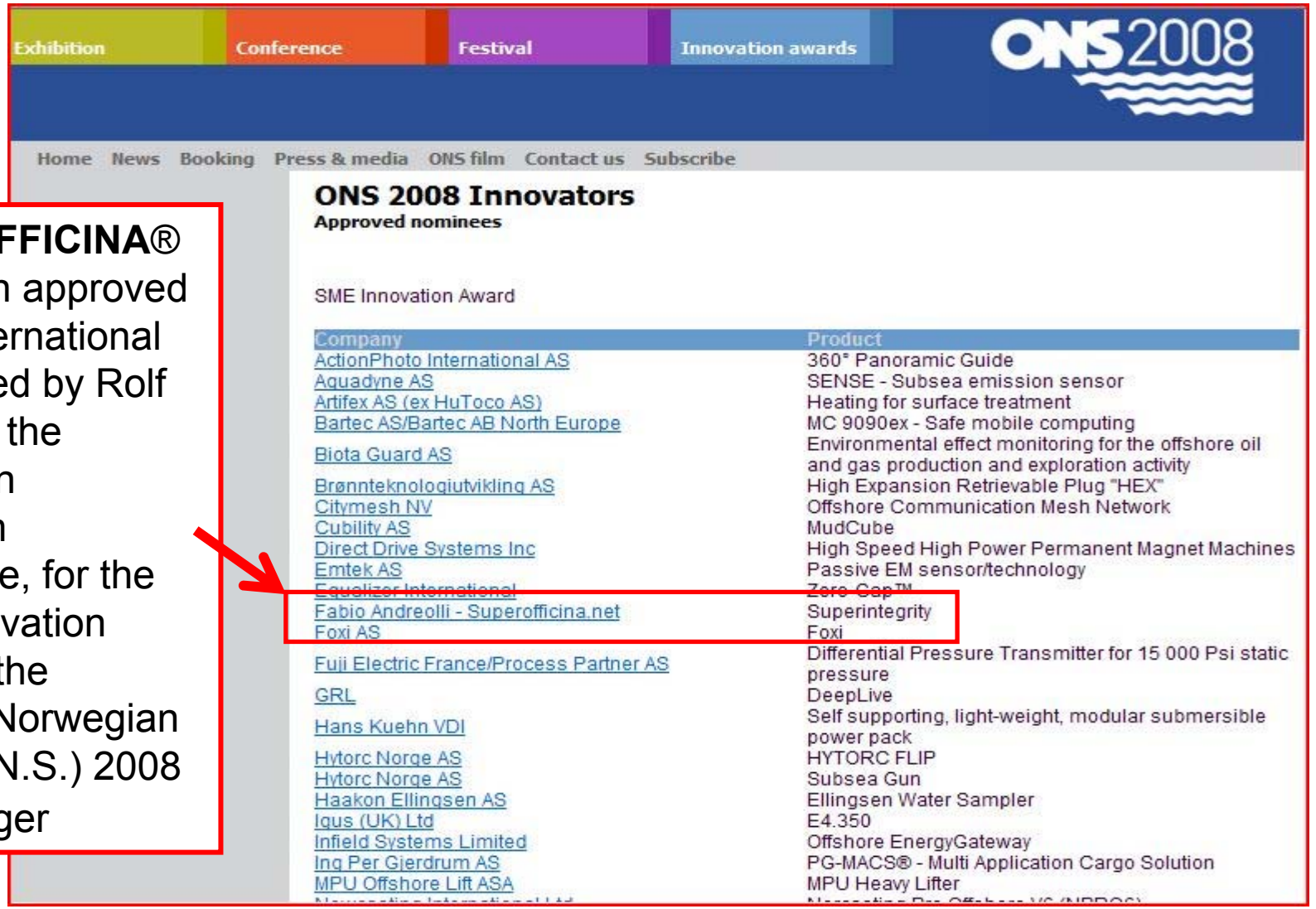
Cost	SUPEROFFICINA®-*Superintegrity* is available in two versions in a multitude of configurations so that the appropriate combination of performance versus cost is available for any pipeline. The *basic version* is a software-only system relying on the existing pipeline instrumentation and SCADA or BPCS for operating data (i.e., no cost associated with remote data acquisition and extra instrumentation). Unlike models S*uperintegrity* does not rely on detailed pipeline simulation which typically requires numerous hours of tuning and extensive controller training. *Superintegrity basic version* can be quickly installed depends from the plant extension. The *Superintegrity* ***extended version***, will have different initial cost, by using dedicated field sensors, logic solvers and final elements including cabling and connections . Larger size systems cost more than a smaller one because of the extra hardware cost including maintenance cost.

WHISHFUL THINKING

Working for a constant reduction in oil & gas leaks is one of the most important measures which can reduce the total level of risk in the energy business.

We are looking for fellowship to share experiences, technology transfer and start up together a technology network

SUPEROFFICINA® have been approved by the international jury,chaired by Rolf Wiborg of the Norwegian Petroleum Directorate, for the SME Innovation Award at the Offshore Norwegian Show (O.N.S.) 2008 in Stavanger



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