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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION NIOEC  
NATIONAL IRANIAN OIL ENGINEERING  
& CONSTRUCTION NIOEC

# NIOEC SP

## NIOEC SPECIFICATION FOR PIPELINE AUTOMATIC LEAK DETECTION SYSTEM

FIRST EDITION

DECEMBER, 2006

THIS STANDARD IS THE PROPERTY OF NATIONAL IRANIAN OIL ENGINEERING & CONSTRUCTION NIOEC. IT IS CONFIDENTIAL AND ALL RIGHTS RESERVED TO THE OWNER. NEITHER WHOLE NOR ANY PART OF THIS DOCUMENT MAY BE DISCLOSED TO ANY THIRD PARTY, REPRODUCED, STORED IN ANY RETRIEVAL SYSTEM OR TRANSMITTED IN ANY FORM OR BY ANY MEANS WITHOUT THE PRIOR WRITTEN CONSENT OF THE NATIONAL IRANIAN OIL ENGINEERING & CONSTRUCTION NIOEC

**IN THE NAME OF GOD****FOREWORD**

By their very nature, technical standard specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such standard specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant standard specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the on going projects.

In response to the initiative of the Design Division of the Engineering and Construction Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design Division of the Engineering and Construction Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design Deputy of the Engineering and Construction Director of NIOEC for evaluation and consideration.

**S. R. KASAEIZADEH**



**EXECUTIVE DIRECTOR**

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## NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) REMARKS RELATED TO EACH REVISION SHOW A BRIEF DESCRIPTION. THESE REMARKS SHALL BE INTERPRETED IN CONJUNCTION WITH THE REVISED TEXT MARKED BY REVISION NUMBERS.
- 3) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 4) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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## 1. SCOPE

This specification defines NIOEC'S minimum requirements for the selection and engineering of automatic pipeline leak detection systems (LDS).

Deviations from this specification will only be permitted on obtaining written approval from NIOEC.

## 2. REFERENCES

Throughout this specification the following dated and undated standards and codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this specification.

For undated references, the latest edition of the referenced document (including any supplements and amendments) applies. For dated references, the edition cited applies.

The applicability of changes in the dated references that occur after the cited date shall be mutually agreed upon by NIOEC and the vendor /contractor.

### ANSI (AMERICAN NATIONAL STANDARDS INSTITUTE)

### API (AMERICAN PETROLEUM INSTITUTE)

|              |                                                                                                 |
|--------------|-------------------------------------------------------------------------------------------------|
| RP 500 A/B/C | "Classification of Areas for Electrical Installation in Refineries/Pipeline/Offshore Platforms" |
| RP 551       | "Process Measurement Instrumentation"                                                           |
| RP 1113      | "Developing a Pipeline Supervisory Control System"                                              |
| RP 1119      | "Training and Qualification of Liquid Pipeline Operators"                                       |
| RP 1120      | "Training and Qualification of Liquid Pipeline Maintenance Personnel"                           |
| PUBL 1130    | "Computational Pipeline Monitoring for Liquids Pipelines"                                       |
| PUBL 1149    | "Pipeline Variable Uncertainties and Their Effects on Leak Detectability"                       |
| PUBL 1155    | "Evaluation Methodology for Software Based Leak Detection Systems"                              |

**BSI (BRITISH STANDARDS INSTITUTION)**

- BS 5345 "Code of Practice for Selection, Installation and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmosphere (Other than Mining Applications or Explosive Processing and Manufacturing)"
- BS 4683 "Specification for Electrical Apparatus for Explosive Atmosphere" (1971)

**CENELEC (EUROPEAN COMMITTEE FOR STANDARDIZATION OF ELECTROTECHNIQUE)**

- EN 50.014 "General Requirements"
- EN 50.018 "Flame-Proof Enclosure 'd'"
- EN 50.020 "Intrinsic Safety 'i'"

**IEC (INTERNATIONAL ELECTRO TECHNICAL COMMISSION)**

- 60529 "Enclosure Protection Classification".

**ISA (INSTRUMENT SOCIETY OF AMERICA)**

- S 5.1 "Instrumentation Symbols and Identification"
- S 5.3 "Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems"
- S 5.4 "Instrument Loop Diagrams"
- RP 12.6 "Installation of Intrinsically Safe Instrument Systems in Class 1 Hazardous Locations"

**NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)**

- NFC # 496 "Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations" (1982)
- NFC # 497 A "Classification of Class 1 Hazardous (Classified) Locations for Electrical Installation Area" (1986)

**NIOEC SP (NIOEC SPECIFICATIONS)**

[NIOEC-SP-70-01](#) "Specification for Instrumentation"

[NIOEC-SP-00-10](#) "Specification for Units"

**UL (UNDERWRITERS' LABORATORY)**

UL-913 "Intrinsically Safe Apparatus and Associated Apparatus, for Use in Class 1, 2 and 3, Division 1, Hazardous (Classified) Locations" (1988)

**3. UNITS**

International System of Units (SI) shall be used in accordance with [NIOEC-SP-00-10](#), unless otherwise specified.

**4. DEFINITIONS****4.1 Purchaser**

In cases where this specification is part of a direct order, Purchaser shall mean National Iranian Oil Engineering and Construction (NIOEC). Where this specification forms part of contract documents, Purchaser shall mean Contractor. In references to inspection by purchaser when this specification forms part of contract documents this shall be construed to mean that NIOEC shall also have the right of inspection.

**4.2 Reliability**

Reliability is defined as a measure of the ability of a leak detection system to render accurate decisions about the possible existence of a leak on the pipeline, while operating within an envelope established by the leak detection system design. It follows that reliability is directly related to the probability of detecting a leak, given that a leak does in fact exist, and the probability of incorrectly declaring a leak, given that no leak has occurred. A system is considered to be more reliable if it consistently detects actual leaks without generating incorrect declarations. Conversely, a system which tends to incorrectly declare leaks is often considered to be less reliable. This is particularly true in cases where it is difficult for the pipeline operator to distinguish between actual leaks and incorrect declarations. On the other hand, a high rate of incorrect leak declarations might be considered less significant if the pipeline operators have access to additional information that can be used to verify or disqualify a leak alarm.

Systems that limit or inhibit alarm generation in response to certain conditions of pipeline operation are not necessarily less reliable. Reliability pertains only to the functionality of the leak detection

software without regard to Supervisory Control and Data Acquisition System (SCADA) performance, availability of the pipeline instrumentation and communication equipment, or any other factor beyond the control of the leak detection system vendor.

Such factors involve a separate category of performance, namely robustness.

The reliability of a leak detection system usually depends upon a number of parameter settings (e.g. decision thresholds, filter characteristics, and so forth) as well as all of the suitable leak detection techniques employed for the operational characteristics of the target pipeline system. In some cases, a pipeline operator must decide whether to use settings that cause frequent alarms during normal pipeline operations, or to use other settings that are less likely to cause alarms, but might delay or even fail to alarm when a leak is present. Many systems also make automatic adjustments to decision thresholds and other parameters in order to reduce the likelihood of generating alarms during defined operating conditions. When such adjustments are made, a corresponding penalty is normally incurred in some other aspect of performance. For example, decisions based on longer observation intervals might make a particular system less susceptible to random instrumentation errors or disturbances caused by normal pipeline operations, but this performance gain is achieved at the expense of longer response time and the risk of greater fluid loss if a leak should occur.

Reliability can be managed through the use of operator response criteria and procedures. Such procedural methods, unless embodied within the leak detection software itself and performed automatically by the system, do not serve to discriminate between leak detection systems with regard to performance. On the other hand, if additional information is available from the leak detection, SCADA, or other systems, then reliability may be better managed.

### 4.3 Sensitivity

Sensitivity is defined as a composite measure of the size of leak that a system is capable of detecting, and the time required for the system to issue an alarm in the event that a leak of that size should occur. The relation between leak size and response time is dependent upon the nature of the leak detection system.

In some cases there is a wide variation in response time as a function of leak size. In other cases the response time is relatively independent of leak size.

However, there are no known systems that tend to detect small leaks more quickly than large leaks. Frequently during the specification process, users attempt to define leak detection performance in terms of detecting a particular leak flow rate within a specified minimum period of time. Although sensitivity expressed in such terms certainly represents one aspect of performance, its importance can vary depending on the nature of the leak detection system and the operating characteristics of the target pipeline system. The correlation between leak size and response time can be highly

dependent upon the leak detection techniques employed. It is also important to recognize that adjustments made in the interest of improving sensitivity can have a corresponding and not necessarily beneficial effect on other aspects of performance.

In practice, most systems can be set up to achieve various levels of sensitivity, provided the minimum detectable leak size and minimum attainable response time are not violated. The leak detection system vendor, and possibly the pipeline operator, can affect these characteristics by adjusting leak detection thresholds, filter characteristics or other parameters. Appropriate settings for these thresholds are usually dependent upon factors such as the SCADA system's scan time, instrument placement, fluid types, and so forth.

Refer to Figures 2 and 3 of API Publication 1155 for illustrations of the variables affecting minimum detectable leak size and minimum attainable response time for any given pipeline.

#### 4.4 Accuracy

Accuracy is the validity of leak parameter estimates i.e., leakage rate, total volume lost, type of fluid lost, and leak location within the pipeline network.

From a strictly mechanical point of view, leak rate depends upon the magnitude and shape of the perforation, pipe environment, fluid characteristics and pressure at the leak site. If the location of a leak is known, the leak flow rate can be used to determine resultant disturbances in pressure, flow rate, and temperature at other points on the pipeline. Software based leak detection systems, on the other hand, deal with quite the opposite situation. Although these systems approach their task in a wide variety of ways, the one thing they all have in common is that they must operate with no prior knowledge of the size or location of a leak, should one occur. Thus, a particular system might calculate a leak flow rate to compensate for a difference between observed and expected values of pressure or flow at certain points on the pipeline. This effective leak flow rate might then be used to estimate the location of the leak and/or the volume loss related to the leak. Another system, operating on the same pipeline, might estimate total fluid volume lost on the basis of metered volumes and calculated changes in line pack, without ever attempting to directly estimate leak flow rate or location.

#### 4.5 Robustness

Robustness is defined herein as a measure of the leak detection system's ability to continue to function and provide useful information, even under changing conditions of pipeline operation, or in conditions where data is lost or suspect. A system is considered to be robust if it continues to function under such less than ideal conditions. On the other hand, if the system disables certain functions, it might then achieve better reliability, but would be considered less robust.

The distinction between reliability and robustness is significant. Reliability is a measure of performance within a specified operational envelope. Robustness is a measure of the effective size of the operational envelope. For example, consider the following hypothetical leak detection systems:

**System I:** This system employs a sensitive leak detection algorithm. The system is normally very reliable, but will frequently generate alarms during certain normal pipeline operations.

**System II:** This system employs an alternative algorithm which is somewhat less sensitive than that of System I, but generates only a fraction of the alarms.

**System III:** This system employs the same sensitive leak detection algorithm as System I, but inhibits leak detection during pipeline operations that can cause it to generate alarms.

**System IV:** This system normally employs the same sensitive leak detection algorithm as System I, but switches to the less sensitive algorithm of System II when it senses conditions that generate alarms.

In this example, the designers of System I have sacrificed a degree of reliability in order to maintain a high level of sensitivity, whereas the designers of System II have chosen to sacrifice a degree of sensitivity in order to achieve a high level of reliability. By simply disabling the leak detection function under certain conditions, the designers of System III have sacrificed a degree of robustness in order to achieve higher levels of reliability and sensitivity. The example of System IV represents an attempt to selectively trade sensitivity and/or reliability in order to achieve a more robust system. Although techniques vary between different software based leak detection methodologies, most attempt to achieve an acceptable tradeoff between reliability, sensitivity, accuracy, and robustness by sensing conditions of pipeline operation that cause alarms and making temporary parameter adjustments or disabling certain functions as required. Prior to the selection of a methodology for a given pipeline system, it is important that the pipeline company understand the way all operating conditions are handled by that methodology. This understanding will help the pipeline company to determine if a particular solution is consistent with the target pipeline's operational characteristics, as well as the company's expectations.

The reliability of a pipeline's communication, SCADA, and instrumentation systems can also have a dramatic effect on the utility of a software based leak detection system. A more robust system is one that is less likely to exhibit loss of functionality during periods of partial data outages caused by instrument failures, communication anomalies, routine maintenance, and so forth. Systems that continue to operate during outage periods or transient conditions on the pipeline might employ different settings for thresholds, filter characteristics, and other parameters. This usually results in some degradation of the system's sensitivity, accuracy, and/or reliability. In such cases, robustness is enhanced at the expense of other aspects of performance.