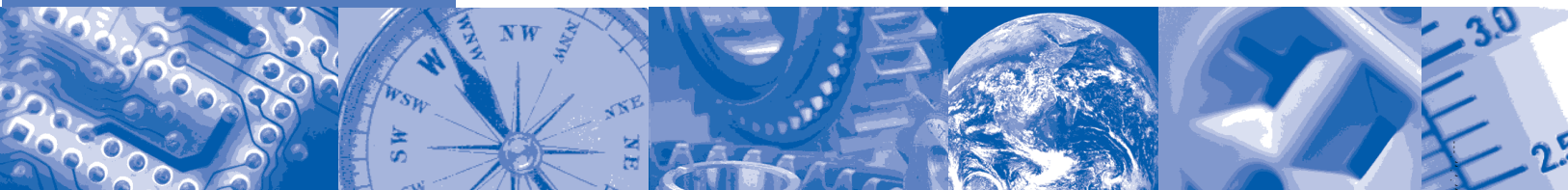


ANSI/ISA-RP12.13.02-2003 (IEC 61779-6 Mod)

Formerly ISA-RP12.13, Part II-1987



Recommended Practice for the Installation, Operation, and Maintenance of Combustible Gas Detection Instruments



ISA—The Instrumentation,
Systems, and
Automation Society

Approved 26 February 2003



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ANSI/ISA-RP12.13.02 (IEC 61779-6 Mod)
Recommended Practice for the Installation, Operation, and Maintenance of Combustible Gas
Detection Instruments

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ISA
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, North Carolina 27709
USA

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Foreword

All text of IEC 61779-6 is included in this document. U.S. National Deviations are shown by ~~strikeout~~ through deleted text and underline under added text. Tables or portions of tables that are to be deleted are shown as shaded; figures to be deleted are marked with the overlay “Figure X Deleted.” All added tables are numbered by a table number corresponding to the applicable subclause for improved clarity and are NOT underlined. Notes appear in the table titles showing the tables as added material.



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Introduction

Part 6 (IEC 61779-6 Mod)

Electrical apparatus for the detection and measurement of flammable gases — Part 6: Guide for the selection, installation, use, and maintenance of apparatus

Flammable gas detection apparatus may be used whenever there is the possibility of a hazard to life or property caused by the accumulation of a flammable gas-air mixture. Such apparatus can provide a means of reducing the hazard by detecting the presence of the flammable gas and issuing suitable audible or visual warnings. Gas detectors may also be used to initiate specific precautions (for example plant shutdown, evacuation, and operation of fire extinguishing procedures).

Apparatus may be used to monitor a gas atmosphere below the lower flammable limit in circumstances where accumulation of gas may result in a concentration of the gas/air mixture to potentially explosive levels.

Performance requirements for gas detecting apparatus are set out in ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod).



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1 General

1.1 Scope

1.1.1 ~~This part of IEC 61779~~ ANSI/ISA-RP12.13.02 (IEC 61779-6 Mod) gives guidance on the selection, installation, use, and maintenance of electrically operated group II apparatus for the detection and measurement of flammable gases complying with the requirements of ~~IEC 61779-1 to IEC 61779-5~~ ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod). It is a compilation of practical knowledge to assist the user, and applies to apparatus, instruments and systems that indicate the presence of a flammable or potentially explosive mixture of gas or vapour with air by using an electrical signal from a gas sensor to produce a meter reading, to activate a visual or audible pre-set alarm or other device, or any combination of these.

NOTE — When in classified areas, the apparatus should be so installed and used that it is not capable of itself igniting a flammable gas-air mixture. It should therefore comply with the requirements of ~~IEC 60079-10~~ ANSI/NFPA 70, Articles 500-505.

For the purpose of this document flammable gases shall include flammable vapours.

1.1.2 This document applies only to group II apparatus intended for use in industrial and commercial safety applications, involving areas classified in accordance with ~~IEC 60079-10~~ ANSI/NFPA 70, Articles 500-505.

For the purpose of this document, apparatus includes

- a) fixed apparatus;
- b) transportable apparatus; and
- c) portable apparatus.

1.1.3 This document is not intended to cover the following:

- a) Apparatus intended only for the detection of non-flammable toxic gases
- b) Apparatus of laboratory or scientific type intended only for analysis or measurement purposes
- c) Apparatus intended for underground mining applications
- d) Apparatus intended for applications in explosives processing and manufacture
- e) Apparatus intended only for process control applications
- f) Apparatus intended for the detection of a potentially flammable atmosphere resulting from dust or mist in air

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ~~part of IEC 61779~~ document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this ~~part of~~

IEC 61779 document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards. ANSI maintains registers of currently valid U.S. National Standards.

IEC 60050(426):1990, International Electrotechnical Vocabulary (IEV) - Chapter 426: Electrical apparatus for explosive atmospheres

IEC 60079 (all parts), Electrical apparatus for explosive gas atmospheres

ANSI/ISA-12.00.01-2002 (IEC 60079-0 Mod):1998, Electrical apparatus for Use in Class I, Zones 0 & 1 Hazardous (Classified) Locations: explosive gas atmospheres—Part 0: General requirements

ANSI/ISA-TR12.24.01-1998 (IEC 60079-10 Mod):1995, Electrical apparatus for explosive gas atmospheres—Part 10: Classification of hazardous areas Recommended Practice for Classification of Locations for Electrical Installations Classified as Class I, Zone 0, Zone 1, or Zone 2

IEC 60079-19:1993, Electrical apparatus for explosive gas atmospheres - Part 19: Repair and overhaul for apparatus used in explosive atmospheres (other than mines or explosives)

IEC 60079-20:1996, Electrical apparatus for explosive gas atmospheres—Part 20: Data for flammable gases and vapours, relating to the use of electrical apparatus. NFPA 497-1997, Recommended Practice for the Classification of Flammable Liquids, Gases, Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.

ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod):1998, Electrical apparatus for the detection and measurement of flammable gases

2 Definitions

For the purpose of this ~~part of IEC 61779 document~~, the following definitions apply.

2.1 aspirated apparatus:

~~combustible gas detecting~~ apparatus that obtains the gas by drawing it to the gas sensor – for example by means of a hand-operated or electric pump.

2.2 catalytic sensor:

sensor, the operation of which depends upon the oxidation of gases on an electrically heated catalytic element.

2.3 clean air:

air that is free of flammable gases and interfering or contaminating substances.

2.4 continuous duty apparatus:

~~combustible gas detecting~~ apparatus that is powered for long periods of time, but may have either continuous or intermittent sensing.

2.5 continuous sensing:

mode of operation in which power is applied continuously to the sensing element and readings are taken continuously.

2.6 diffusion apparatus:

apparatus in which the transfer of gas from the atmosphere to the gas sensing element takes place by ~~diffusion~~ random molecular movement, i.e., under conditions in which there is no aspirated flow.

2.7 electrochemical sensor:

sensor, the operation of which depends upon changes of the electrical parameters of electrodes placed in an electrolyte due to redox reactions of the gas on the surface of the electrodes.

2.8 electromagnetic radiation absorption sensor:

sensor, the operation of which depends upon the absorption of electromagnetic radiation by the gas being detected.

2.9 explosion protected apparatus:

apparatus incorporating a type of protection listed in ANSI/ISA-12.00.01-2002 (IEC 60079-0 Mod) ~~covered by the IEC 60079 series of standards.~~

2.10 explosive gas atmosphere:

mixture with air, under normal atmospheric conditions, of flammable material in the form of gas or vapour, in which, after ignition, combustion spreads throughout the unconsumed mixture.

NOTE 1 — This definition specifically excludes dusts and fibres in suspension air. Mists are not covered by this standard.

NOTE 2 — Although a mixture that has a concentration above the upper explosive limit (see 2.1.9) is not an explosive atmosphere, in certain cases for area classification purposes, it is advisable to consider it as an explosive gas atmosphere.

NOTE 3 — Normal atmospheric conditions include variations above and below reference levels of 101.3 kPa and 20 °C provided the variations have a negligible effect on the explosive properties of the flammable materials.

2.11 explosive range:

range of gas or vapour mixtures with air between the explosive (flammable) limits.

2.12 fixed apparatus:

apparatus which is intended to have all its parts permanently installed.

2.13 flashpoint:

lowest liquid temperature at which, under certain standardized conditions, a liquid gives off vapours in a quantity such as to be capable of forming an ignitable vapour/air mixture.

2.14 group II apparatus:

electrical apparatus for places with a potentially explosive atmosphere, other than mines susceptible to firedamp.

2.15 infrared absorption sensor:

sensor, the operation of which depends upon the absorption of infrared radiation by the gas being detected.

2.16 intermittent sensing:

mode of operation in which the power or flow to the sensor is applied intermittently according to a predetermined cycle and readings taken at the predetermined cycle.

2.17 lower flammable limit (LFL):

volume ratio of flammable gas or vapour in air below which an explosive gas atmosphere does not form, expressed as a percentage (see Annex A).

NOTE — This is also known as lower explosive limit (LEL).

2.18 open path infrared sensor:

sensor capable of detecting gas at any location along an open path traversed by an infrared beam.

2.19 portable apparatus:

spot reading or continuous duty apparatus that has been designed to be readily carried from place to place and to be used while it is being carried. Portable apparatus is battery operated and includes, but is not limited to

- a) hand-held apparatus, typically less than 1 kg, suitable for single-handed operation;
- b) personal monitors, similar in size and mass to the hand-held apparatus, that are continuously operating (but not necessarily continuously sensing) while they are attached to the user; and
- c) larger apparatus ~~up to 5 kg~~ that can be operated by the user while it is suspended by hand, by a shoulder strap or by a carrying harness; it may or may not have a hand directed probe.

2.20 relative density:

density of gas or vapour relative to the density of air at the same pressure and at the same temperature (air is equal to 1.0).

2.21 release rate:

quantity of flammable gas or vapour emitted per unit time from the source of release which itself could be a liquid surface.

2.22 remote sensor:

sensor which is not integral with the main body of the apparatus.

2.23 sample line:

~~pipeline by a means~~ by of which the gas being sampled is conveyed to the sensor.

2.24 sampling probe:

separate sampling line, that may or may not be supplied with a portable apparatus that is attached to the apparatus as required.

NOTE — The sampling probe is usually short (for example of the order of 1 m) and rigid (for example it may be telescopic) but may be connected by a flexible tube to the apparatus.

2.25 semi-conductor sensor:

sensor, the operation of which depends upon changes of the electrical conductance of a semi-conductor due to chemisorption of the gas being detected at its surface.

2.26 sensor:

assembly in which the sensing element is housed that may contain associated circuit components.

2.27 sensing element:

that part of a sensor that reacts in the presence of a flammable gas mixture to produce some physical or chemical change that can be used to activate a measuring or alarm function, or both.

2.28 single point sensor:

sensor capable of detecting gas at a single point location.

2.29 source of release:

point or location from which a flammable gas, vapour or liquid may be released into the atmosphere such that an explosive gas atmosphere could be formed. [IEV 426-03-06, modified].

2.30 spot reading apparatus:

apparatus intended to be used for short periods of time as required (typically 5 min or less).

2.31 thermal conductivity sensor:

sensor, the operation of which depends upon the change of heat lost by conduction of an electrically heated element located in the gas to be measured, compared with that of a similar element located in a reference gas cell.

2.32 transportable apparatus:

apparatus not intended to be portable, but which can be readily moved from one place to another.

2.33 upper flammable limit (UFL):

volume ratio of flammable gas or vapour in air above which an explosive gas atmosphere does not form, expressed as a percentage (see Annex A).

NOTE — This is also known as upper explosive limit (UEL).

2.34 ventilation:

movements of air and replacement with fresh air due to the effects of wind, temperature gradients or artificial means (for example fans or extractors).

3 Measuring principles

The measuring principles of various sensors are given below as well as typical advantages and disadvantages of each.

3.1 Catalytic sensor

The principle of operation of the catalytic sensor depends upon the oxidation of flammable gas at the surface of an electrically heated catalytic element (filament or bead). This oxidation causes, for example the temperature of the sensing element to change as a function of the concentration of gas so detected. The resultant change of electrical resistance is determined. A reasonable concentration of oxygen in the order of 10 % or greater is required for catalytic sensors to operate.

By their very nature, catalytic sensors will directly detect flammable gases; the other types of sensors described in 3.2 to 3.6 indirectly infer the presence of flammable gases by the response of the sensor to other gas properties.

Since oxidation depends upon the presence of oxygen, detection apparatus should use only this type of sensor for gas concentrations up to the lower flammable limit.

The catalytic sensor may be used in either

- a) diffusion mode; or
- b) aspirating mode.

3.1.1 Advantages

The sensors detect flammable gases by a process of combustion and are suitable for the detection of a wide range of flammable gases but with possible variations in sensitivity.

3.1.2 Disadvantages

The main disadvantages with catalytic sensors are the following:

- a) Range limitation

The catalytic sensor depends upon catalytic oxidation for its principle of operation and it functions only when sufficient oxygen is present. This type of sensor should be used for the detection of gas/air mixtures up to the lower flammable limit.

WARNING – ABOVE THE LOWER FLAMMABLE LIMIT, A CATALYTIC SENSOR MAY RESPOND AMBIGUOUSLY AND IN SOME CASES THE INSTRUMENT MAY ERRONEOUSLY INDICATE THAT THE FLAMMABLE GAS AND AIR MIXTURE IS BELOW THE LFL.

b) Interfering gases and vapours

If the atmosphere to be monitored contains gas(es) that dilute(s) or displace(s) air, for example nitrogen or carbon dioxide, the catalytic sensor may give a low or even zero response. Similar problems may occur in steam-laden atmospheres, quite often owing to saturation of when condensed moisture physically blocks the sintered flame arrestor ~~due to condensation~~. High concentrations of inert gas (for example argon or helium) may also change the thermal balance of the sensor resulting in apparent reading of combustible gas.

c) Inhibition (catalyst poisoning)

Catalytic sensors are susceptible to permanent or temporary inhibition of the catalyst by certain airborne contaminants such that the sensor may eventually produce low, or zero response to the presence of gas.

NOTE — For this reason, it is therefore important that all catalytic gas detection apparatus is regularly tested in accordance with 9.2.

This inhibition may be permanent or temporary according to the nature of the contaminant. Permanent inhibition, usually known as "catalyst poisoning", may result from exposure to such substances as silicones, tetraethyl lead, sulphur compounds and phosphate esters. In some cases substances such as halogenated hydrocarbons may cause temporary inhibition.

While many catalytic sensors are highly resistant to such contaminants and require no additional protection in this regard, those that are not may be protected, in some cases, by the use of activated carbon or other types of filter. However, carbon filters should be used with great care because, while they may offer excellent protection from contaminants, they may also prevent the detection of most hydrocarbons other than methane and may cause considerably increased response times. ~~Their~~ Carbon filter performance may also be affected by the level of humidity in the atmosphere.

An alternative technique sometimes used to reduce the effects of inhibition is the electrical operation of the sensor in intermittent mode. However, there are circumstances in which such sensors may give a false response, for example when they are suddenly exposed to a high concentration of gas during the "power-off" part of the switching cycle. Particular caution is necessary when using such portable apparatus in leak-detection mode or in similar operations.

The manufacturer's guidance should be sought where the presence of contaminants is suspected, or where temporary or permanent inhibition is experienced.

3.2 Thermal conductivity sensor

The principle of operation of the thermal conductivity sensor depends upon the heat loss by conduction of an electrically heated resistance element (i.e., filament, bead or thin film resistor) located in a gas sample stream of fixed velocity or in a diffusion chamber. The resulting change of electrical resistance is then determined.

This type of sensor is best suited for detecting individual gases of high or low thermal conductivity relative to air.

Thermal conductivity sensors are suitable for monitoring those gases whose thermal conductivity differs substantially from that of air (where air is the reference environment) but only at relatively high concentrations, usually above the lower flammable limit. Apparatus incorporating thermal conductivity sensors should not be used for measuring gas concentrations below the LFL except in the case of gases such as hydrogen for which such sensors are especially sensitive.

Errors may result if

- a) the apparatus is used to attempt to detect gases for which it is not calibrated;
- b) a flow-sensitive type of thermal conductivity sensor is used and the gas sample flow is not stable;
- c) the gas sample is not conditioned to remove water vapour or other interfering vapours or gases, some of which may even result in negative response;
- d) there are variations in ambient temperature without compensatory ambient temperature control on the complete sensor; and
- e) additional gases of different thermal conductivities compensate the resulting conductivity so that the signal may even be zero.

3.2.1 Advantages

The sensor is capable of measuring high concentration and is independent of the oxygen level in the gas-flow.

3.2.2 Disadvantages

Disadvantages with the use of thermal conductivity sensors include the following:

- a) These sensors are not selective for individual gases.
- b) The sensitivity is often limited and the detection limit may exceed the LFL unless the thermal conductivity of the gas is sufficiently different from that of air.
- c) The thermal conductivities of flammable gases differ widely. The lighter gases, for example methane and hydrogen, are more conductive than air, whereas the heavier gases are less conductive. The response to a gas mixture is therefore indeterminate unless the proportions of the constituent gases in the mixture are known. In the worst case, a mixture of high and low conductivity gases could produce no instrument response.
- d) This type of sensor is essentially dependent on thermal conduction and convection from a heated filament and is therefore likely to give misleading results if the recommended conditions of gas flow are not maintained as per the manufacturer's instructions.
- e) Some instruments specifically rely on convection and will be sensitive to orientation.

3.3 Electromagnetic radiation absorption sensor – usually infrared

The principle of operation of this type of sensor depends upon the absorption of energy of a beam of electromagnetic radiation by the gas being detected. Most existing instruments operate within the IR spectrum.

Detection apparatus with electromagnetic sensors may take various forms but may be categorized as

- a) specifically adapted analysers with sampling systems;
- b) single-point, self-contained electromagnetic detection apparatus suitable for installation in potentially explosive atmospheres; and
- c) light "pipes" – for example a fibre optic cable which directs an electromagnetic light source from a control unit to a sensor cell at a remote location.

In cases a), b) and c) the absorption of electromagnetic radiation by the gas is detected by spectrometric means and produces an electrical signal to provide indications of gas concentrations and alarms.

Electromagnetic sensors may be used for the detection of most flammable gas(es) in any specified range of concentrations up to 100 % (v/v) with the exception of hydrogen.

NOTE — Open-path, electromagnetic radiation detection apparatus differs from the other types mentioned in this standard in that it does not measure the concentration of gas at a particular point location, but rather measures the path integral of gas concentration along an investigative beam. It is therefore capable of detecting the presence of gas over a wider area than other types. However, it is inherently not capable of distinguishing between a high concentration of gas occupying a short section of the open path, and a low concentration of gas occupying a longer section of the path, and therefore does not comply with ~~IEC 61779-1, IEC 61779-4 and IEC 61779-5~~ Parts 1, 4, and 5 of ANSI/ISA-12.13.01 (IEC 61779-1 through 5 Mod).

3.3.1 Advantages

The sensor measures the concentration of the specific gas for which it is calibrated independent of oxygen concentration. By appropriate selection of wavelength, specific gases can be detected. Most flammable gases of the hydrocarbon family absorb radiation in the infrared part of the electromagnetic spectrum. By selection of the optical path length, concentrations from 0 % to 100 % v/v can be measured. Response time is limited by the time taken for gas to be introduced into the optical path which can be fast. However, in practice, weather protection housings, gas filters and hydrophobic barriers, where fitted, will limit the response times attainable.

Certain types of sensors using advanced signal processing have self-diagnosing and self-calibrating capabilities, thereby reducing the need for human intervention in the absence of malfunction alarms. Other advantages include

- a) high stability capability;
- b) no ambiguity at concentrations above the LFL;
- c) immunity to poisoning effects;
- d) reduced maintenance capability due to modern technologies, for example automatic calibration self-check, etc.; and
- e) availability of warnings to detect failure of the IR source or excessive contamination of the optical system.

3.3.2 Disadvantages

Infrared sensors are calibrated to detect a particular gas or, in some cases, a limited range of gases. Other gases will not be detected if their infrared absorption band is outside that of the calibration bandwidth. Apparatus incorporating such sensors should therefore be used only for the detection of gas mixtures for which they have been calibrated. When filters are used to keep optical components clean, they may be blocked under excessively dirty conditions.

Serious errors are likely to occur with some detectors due to the presence of water vapour or interfering gases or both.

This sensor is not suitable for measuring hydrogen.

Some types of infrared sensors, particularly open-path designs, are sensitive to misalignment caused by shock and vibration.

3.4 Semi-conductor sensor

The principle of operation of the semi-conductor sensor depends upon changes of electrical conductance that occur by chemisorption when the heated semi-conductor sensing element is exposed to gas. Gas concentrations are deduced from the measured change of conductivity.

Semi-conductor sensors may be used in either diffusion mode or in a sampling system.

This type of sensor is normally used for the detection of a specified gas in a nominated range of concentrations.

3.4.1 Advantages

Semi-conductive sensors are sensitive to a wide range of gases and produce large signal changes at low gas concentrations.

3.4.2 Disadvantages

Semi-conductor sensors for flammable gases are generally non-specific, vulnerable to both humidity changes and interfering gases and may exhibit drift both of zero and span. Some gases, for example NO_2 , produce negative signals.

NOTE — Normally, the manufacturer will give guidance on substances that will inhibit operation of the sensor or produce false indications.

3.5 Electrochemical sensors

The principle of operation of the electrochemical sensor depends upon the change of the electrical parameters of electrodes when a specific gas is present. The change in the electrical parameters occurs due to a chemical redox reaction on the surface of electrodes placed in an electrolyte. Electrodes and electrolyte are usually confined in semi-permeable membranes.

3.5.1 Advantages

Electrochemical cells are compact, require little power, and have a high sensitivity to certain gases.

3.5.2 Disadvantages

Disadvantages include the following:

- a) Electrochemical cells are incapable of detecting the most simple hydrocarbons (for example methane, ethane, propane, etc.).
- b) The electrochemical cell can gradually be consumed.
- c) Electrochemical cells may detect other interfering gases.
- d) Periodic adjustment is necessary to correct for drifts in zero and span.
- e) Response and recovery times are comparatively slow (typically >30 s).
- f) Low temperature operations ($\leq 15^\circ\text{C}$) and high temperature operations ($> 50^\circ\text{C}$) may be precluded by electrolyte properties.

3.6 Flame ionization detectors (FID)

The operating principle of the flame ionization detector depends upon the ionization of the organic compounds. The ion cloud so formed migrates under the potential gradient between the electrodes in the ionization chamber, resulting in an electric current. This current is proportional to the concentration of gas/vapour in the gas stream.

This type of sensor is used for the detection of gas/air mixtures up to the lower flammable limit.

3.6.1 Advantages

This type of sensor is used where high sensitivity, wide measuring range, small measuring uncertainty, poison resistance and fast response time are of main interest.

The sensor is suitable for the measuring range from ml/m^3 (10^{-6}) up to the lower flammable limit.

3.6.2 Disadvantages

The principle of operation is not selective because generally all organic compounded carbons will cause a signal. If different gases or vapours are expected at the place of operation, the sensor should be calibrated for that gas or vapour to which the apparatus is least sensitive. These sensors are not suitable for inorganic gases such as H_2 .

The pressure of the gas sample, air and flammable gas should be kept constant, but it should be noted that the flame arrestors used in the sampling line can be soiled and difficulty may be experienced in keeping the sample flow constant.

4 Selection of apparatus

In this clause and clauses 5 and 6, there is a need for documentation of plant information, site information and decisions to be made. Annex B shows a typical check-list for many of these decisions.