Cost comparison of methods of explosion protection
ATEX APPENDIX

A simple introduction to the ATEX directives which are relevant to all methods of protection.

ATEX 100A Directive
Safety of Apparatus

Directive 94/9/EC
Provisional 1 March 1996  Mandatory 1 July 2003
Provisional 1 March 1996  Mandatory 1 July 2003

Essential Safety Requirements (ESR) include:
- Principle of integrated safety
- Consideration of environment
- Marking
- Instructions
- Choice of materials
- Potential ignition sources
- Risk caused by software
- Risk from gas, vapours, dust and dust

ERCERTIFICATION REQUIREMENTS

- Certification by notified body
- Certification by manufacturer
- Unit verification by notified body
d
Note: Internal combustion engines are electrical equipment.

SURFACE INDUSTRY (II)
Equipment category & intended use

<table>
<thead>
<tr>
<th>Equipment category</th>
<th>Level of protection</th>
<th>Area classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>II1 G D</td>
<td>Two independent faults (la)</td>
<td>Zone 0 (gas)</td>
</tr>
<tr>
<td>II2 G D</td>
<td>One fault (lb)</td>
<td>Zone 1 (gas)</td>
</tr>
<tr>
<td>II3 G D</td>
<td>Safe in normal operation (n)</td>
<td>Zone 2 (gas)</td>
</tr>
</tbody>
</table>

Coal mining has categories M1 and M2

ATEX 137A (118A) Directive
Safety of Installation

(Tentative Analysis based on draft document (Dec 98) hence use with care)
(Probable implementation date 1 July 2003)

Requirements
- Assess the risk overall - produce explosion protection document
- Include
  - Probability of explosive atmosphere
  - Probability of ignition source
  - Nature of explosive materials
  - Scale of effect of explosion

IN ADDITION
- Requirements for training and marking

CERTIFICATION REQUIREMENTS

<table>
<thead>
<tr>
<th>Equipment category</th>
<th>1 Electrical</th>
<th>2 Non-electrical</th>
<th>3 Areas of 100A Directive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification by notified body</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Certification by manufacturer</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Unit verification by notified body</td>
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<td>✔️</td>
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<tr>
<td>QA of production by notified body</td>
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<td>✔️</td>
<td>✔️</td>
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<tr>
<td>QA of product by notified body</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>QA by manufacturer</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

Note: Internal combustion engines are electrical equipment.

Covers design of apparatus applicable to European Economic Area plus some others.

Covers installations.
Cost comparison of methods of explosion protection

By
L C Towle BSc CEng MIMechE MIEE MInstMC
Technology Director
The MTL Instruments Group plc

Introduction

The problem with attempting to make a comparison of cost is that there are an infinite number of variations in the way each loop can be constructed. This presentation concentrates on two specific loops, a switch transfer loop and a 4-20 milliamp transmitter loop, because these are representative of a conventional process industry control system.

The costs quoted are ratios rather than absolute values although they are the approximate cost in Pounds Sterling. None of the costs quoted are beyond question but they are the author's best estimate. Possibly this comparison is best used by reading and understanding it as it is presented and then if you consider the values chosen to be unrepresentative, redrawing the diagrams using the different estimates that you have chosen. With the variations tried by the author it is only if one or more of the fundamental assumptions made is challenged that the conclusions are changed significantly.

The paper is presented as a collation of the slides used in presenting the lecture, with a few words of explanation inserted so that the document can stand alone. The diagrams use colour to characterise the methods of protection utilised in accordance with the key below.

This document has been updated in December 1999, in particular the first seventeen slides have been amended and some information on the ATEX directives appended.

It is intended to continuously review this document. If you have any comments or criticisms, (preferably constructive) the author would appreciate receiving them so that they can be incorporated.

<table>
<thead>
<tr>
<th>KEY:</th>
<th>US Ex</th>
<th>Ex e</th>
<th>Ex n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ex d</td>
<td>Ex i</td>
<td>Us ni</td>
</tr>
</tbody>
</table>
**APPARATUS (GAS) GROUPING**

<table>
<thead>
<tr>
<th>Typical gas hazard</th>
<th>IEC 60079-0 CENELEC EN 50014</th>
<th>North America NEC Article 500 (Class I)*</th>
<th>Minimum ignition energy (microjoules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACETYLENE</td>
<td>IIC</td>
<td>A</td>
<td>20</td>
</tr>
<tr>
<td>HYDROGEN</td>
<td>IIC</td>
<td>B</td>
<td>20</td>
</tr>
<tr>
<td>ETHYLENE</td>
<td>IIB</td>
<td>C</td>
<td>60</td>
</tr>
<tr>
<td>PROPANE</td>
<td>IIA</td>
<td>D</td>
<td>180</td>
</tr>
</tbody>
</table>

*North American hazard categories: Class I (Gases & Vapours); Class II (Dusts); Class III (Fibres)

The National Electrical Code currently permits both existing US practice and IEC techniques to be used.

There is no correlation between Gas Group and Ignition temperature.

Areas are classified with regard to the probability of a potentially explosive atmosphere being present and the length of time for which it is likely to exist.
### STANDARDS FOR METHODS OF PROTECTION

<table>
<thead>
<tr>
<th>Standards</th>
<th>Permitted Zone</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explosion prevention &amp; protection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ATEX category</strong></td>
<td><strong>Code</strong></td>
<td><strong>CENELEC EN</strong></td>
</tr>
<tr>
<td>Category M1</td>
<td>50284</td>
<td>-26</td>
</tr>
<tr>
<td>General requirements</td>
<td>50014</td>
<td>-6</td>
</tr>
<tr>
<td>Oil-immersion</td>
<td>50015</td>
<td>-6</td>
</tr>
<tr>
<td>Pressurized</td>
<td>50016</td>
<td>-2</td>
</tr>
<tr>
<td>Powder-filled</td>
<td>50017</td>
<td>-5</td>
</tr>
<tr>
<td>Flameproof</td>
<td>50018</td>
<td>-1</td>
</tr>
<tr>
<td>Increased safety</td>
<td>50019</td>
<td>-7</td>
</tr>
<tr>
<td>Intrinsic safety ia</td>
<td>50020</td>
<td>-11</td>
</tr>
<tr>
<td>Intrinsic safety ib</td>
<td>50020</td>
<td>-11</td>
</tr>
<tr>
<td>Intrinsically safe systems</td>
<td>50029</td>
<td>-25</td>
</tr>
<tr>
<td>Encapsulated</td>
<td>50030</td>
<td>-18</td>
</tr>
<tr>
<td>Type of protection ‘n’</td>
<td>50021</td>
<td>-15</td>
</tr>
</tbody>
</table>

### Codes of Practice

<table>
<thead>
<tr>
<th>Subject</th>
<th>Standard</th>
<th>Code</th>
<th>Sub-division of Type n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification of hazardous areas</td>
<td>-10 -10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical installations</td>
<td>-14 -14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspection and maintenance</td>
<td>-17 -17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repair and overhaul</td>
<td>-19 -19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data for flammable gases</td>
<td>-20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Apparatus Standard

<table>
<thead>
<tr>
<th>Apparatus Standard</th>
<th>CENELEC</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>p</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### General requirements

Some clauses excluded by Intrinsic Safety standard.

### Pressurization Ex p

<table>
<thead>
<tr>
<th>Apparatus Standard</th>
<th>CENELEC</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ex p</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Permitted in Zones 1 and 2**
- **Excludes** gas by positive pressure (50Pa)
- **Includes** continuous dilution and static pressurization
- **Application** Solves otherwise intractable problems such as analytical instruments

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EN50284 and EN1127-1 are also relevant.
**Ex o**

Apparatus Standard
CENELEC EN50015 : 1998
IEC IEC 60079-6 : 1995-04

ATEX Category
2GD

Permitted in Zones 1 and 2 : 21 and 22
Protects by immersion in oil
Application Heavy current switchgear and transformers, very occasionally used for instrumentation

**Oil filling Ex o**

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**Ex q**

Apparatus Standard
CENELEC EN50017 : 1998
IEC IEC 60079-5 : 1997-04

ATEX Category
2GD

Permitted in Zones 1 and 2 : 21 and 22
Protects by submersion in quartz (glass balls)
Application Protection of high power electronics; starters for Ex e lighting

**Sand filling Ex q**

---

**Ex m**

Apparatus Standard
CENELEC EN50028 : 1987
IEC IEC 60079-18 : 1992-10

ATEX Category
2G

Permitted in Zones 1 and 2
Protects by immersion in encapsulant
Application Solenoid valves; power supplies

**Encapsulation Ex m moulding**
A construction technique relying on good quality materials, design and assembly to eliminate any sparks or hot spots

“Erhohete sicherheit” German in origin, means “increased safety”

No discontinuous contacts are permitted so Instrumentation is rarely Ex e protected: i.e. no zero/span potentiometers or switches

Applications include induction motors, lighting fittings, junction boxes, terminal housings and anti-frost heaters

Enclosures need not be strong enough to contain an explosion but must be weatherproof; IP 54 is usual minimum, impact resistant and solvent-proof

Installation is permissible in both Zones 1 and 2

Ex e - increased safety

Ex e

Apparatus Standard
CENELEC EN50019:1994
IEC IEC 60079-7:1980-8
Ed. 2.2 consolidated edition

ATEX Category
2G

Permitted in Zones 1 and 2
Prevents sparking and hot spots by careful construction
Application Motors, lighting and terminal boxes

Increased safety Ex e Erhochte sicherheit

A construction technique:
- No incendive sparks
- No hot surface
- Faults not considered
- Enclosures IP54; 7Nm impact test
- Zone 2 only

Used for: Lighting, junction boxes, rotating machines

Type n principles
Non Incendive

- No incendive sparks
- No hot surfaces

Faults within the apparatus not considered

Restricted live working if 0.9 safety factor applied to cable faults

Requires expertise in preparing system documents

Zone 2 Apparatus Type n

Permitted in Zone 2 only
Utilises relaxed version of almost all methods of protection
Application Everything in Zone 2; large motors very significant

US practice distinguishes between non-arcing (higher currents) and non-incendive circuits.
FM approval standard Class number 3611 Oct. 99 relevant.

Ex n

Apparatus Standard
CENELEC EN50021 : 1999
IEC IEC/TR 60079-17 : 1996-12
ATEX Category
3G

Ex d

Apparatus Standard
CENELEC EN50018 : 1994
IEC IEC 60079-1 : 1998-08
Ed. 3.2 consolidated edition
ATEX Category
2G

Permitted in Zones 1 and 2
Contains explosion prevents propagation
Application Switchgear; higher power instrumentation

Flameproof Ex d Druckfeste

Updated IEC standard expected May-June 2000
This slide is making the point that instrumentation frequently affects area classification. The thermocouple sheath and its coupling to the process pipe both offer possible sources of release.

The question to be answered is what is the area classification both before and after the installation. It may be changed.

In the author’s opinion, thermocouples, orifice plates d.p. cells, control valves etc. all generate their own Zone 1 Division 1 locations. Some equipment such as analysers require very special consideration.
Slides 19 to 24
These slides attempt to summarise the advantages and disadvantages of the different methods of protection. Of necessity they oversimplify some of the situations. There are a number of points which may be disputed but most of the arguments are those generally accepted.

The overall balance is fairly static but with all methods of protection, problems come and go over a period of time. All the CENELEC methods of protection committees are wrestling with the problems of batteries at the present time. Sparking within high voltage Ex e and Ex N motors has created a seemingly insoluble problem.

US Explosionproof (pros & cons)

1. Good robust box (heavy)
2. Very much preferred technique in US
3. Safe area apparatus not certified
4. Frequently not temperature classified
5. More flexible than Ex d e.g. batteries allowed
6. Installation practice and maintenance require skill but this is widely available

Ex d (pros & cons)

1. Good robust box (heavy)
2. User acceptability high in UK
3. Safe area apparatus not certified, cables not certified
4. Temperature classification T6 [normal operation]
5. Best solution for high power sparking apparatus

Ex e (pros & cons)

1. Good enclosures [IP65]
2. Acceptable in most of Europe
3. Not gas conscious; enriched & dust
4. Cables & terminals & junction boxes much more serviceable than Ex d
5. Only technique for high powered batteries
6. No live maintenance

US Explosionproof (pros & cons)

1. Enclosure material choice limited
2. Not always highest gas classification
3. No live maintenance
4. Tapered thread entry for conduit reduces versatility
5. Conduit seals make changes difficult
6. Not acceptable in many areas of the world
### Ex i (pros & cons)

1. Enclosure to suit purpose
2. Suitable Zone 0
3. Usually IIC T4
4. Simple Apparatus rules offer great flexibility
5. Internationally accepted technique
6. Permits live maintenance, personnel safe

1. A low power technique
2. Perceived as complex
3. Temperature class usually T4, CS2 is T5
4. Cable parameters cause concern.
   No problem in IIB,
   Long cables in IIC

### Ex n (pros & cons)

1. Simpler
2. More reliable
3. Lower perceived cost
4. Permits almost anything to the politically astute. Needs good documentation
5. Acceptable UK, Holland, Australia
6. Division 2 practice in North America

1. Lower level of safety
2. No live maintenance
3. Acceptable only in Zone 2 (watch area classification change)
4. Standard attempts to cover relaxed everything
5. Third party certification difficult to obtain to ill defined standard
   No provision for systems
6. Division 2 practice in North America

### US Non Incendive (pros & cons)

1. Simpler
2. More reliable and some live maintenance
3. Lower cost
4. Flexibility high, if certification not required
5. Acceptable in some other parts of the world, if you talk fast

1. Lower level of safety
2. Division 2 restriction can cause problems if classification changes
3. Requires great skill in preparation of certification drawings
4. Drawings impose restrictions if one must be legal
Slides 25 to 28

The general loop sets the scene for the remaining analysis and assumes sixteen transducers feeding into a junction box via a multicore into an interface cabinet.

The assumption is made that the documentation requirement (see 26) the multicore cable (see 27) and the safety bond (see 28) is the same for all methods of protection.

The part cost of the multicore is one of the dominant costs in the whole system and there are very wide differences in...
this cost. However the length of 200 metres and the cost assumed is not unrepresentative and variations in this cost do not significantly affect the overall argument. Theoretically the cost of an intrinsically safe multicore could be lower but in practice it is usual to use an armoured or heavily braided cable to ensure operational integrity.

Great stress has been placed on the cost of intrinsic safety earthing but in practice the need for adequate earthing is independent of the method of protection.

Fig 25A illustrates the earthing and bonding system of a typical plant. The incoming electrical substation transformer usually has a neutral bonded to an earth mat. Other major earth connections are determined by the lightning protection requirements. These earth mats are cross bonded by the structure, deliberate cross connections and less positively via the soil.

Electrical apparatus such as luminaires and motors are bonded to the structure and have a fault return path to the electrical distribution busbar via the cable armour. The safe area structures are normally returned to the power 0V busbar.

The computer 0 volt and cabling screens are returned to the clean 0V busbar which is bonded to the power system at one point; the neutral earth mat bond.

Where a barrier 0V is used it is connected to the clean 0V busbar as illustrated and is not a significant addition.

The costs attributed to part of the interface cabinet and system processor are arbitrary.

These arguments give a base cost per loop of 985.
Slide 29
The additional costs of the explosionproof switch loop are attributed as follows.

- The switch itself would need to be certified.
- The cable between the switch and the junction box would need flexible conduit with stopper boxes.
- Part of the cost of the explosion proof junction box.
- The multicore cable is replaced by conduit and cables which is more expensive than the corresponding multicore and cable trays [a 20% premium is used].
- The need for circuit protection of all leads into hazardous areas is common to all methods of protection. The necessary combination is an isolating switch, a resistor for low voltage faults and a fuse for high power faults. The mounting cost for these is significant.

Slide 30
The significant cost reduction is the absence of the 20% increased cost of conduit over armour.

The assumption is made that American explosionproof boxes and CENELEC flameproof [Ex d] boxes are similar in cost.

Slide 31
Slight reduction in cost by using encapsulated switch with flylead into a lower cost Ex e junction box.

Slide 32
Further reduction in cost of switch and associated lead because it is simple apparatus.

The Ex e junction box and multicore cables are retained because of operational reliability concerns even though theoretically lower cost items could be used.

Increase in cost is the interface or barrier.
Ex d switch loop

<table>
<thead>
<tr>
<th>Hazardous area</th>
<th>Safe area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible Cable protected by flexible conduit, intermediate junction box</td>
<td>Switch to isolate Fuse major fault Resistor (180Ω) minor fault</td>
</tr>
<tr>
<td>Ex d box with glands Specified terminals</td>
<td>GAS BLOCK</td>
</tr>
<tr>
<td>Ex d switch Magnetic or Mechanical via gland</td>
<td>PROCESSOR</td>
</tr>
<tr>
<td></td>
<td>24V</td>
</tr>
</tbody>
</table>

**Cost**

<table>
<thead>
<tr>
<th>Cost</th>
<th>90</th>
<th>80</th>
<th>20</th>
<th>20</th>
<th>210 + 985</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>320</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td>1195</td>
</tr>
</tbody>
</table>

Total

Ex e switch loop

<table>
<thead>
<tr>
<th>Hazardous area</th>
<th>Safe area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flylead protected by flexible conduit (not replaceable)</td>
<td>Switch to isolate Fuse major fault Resistor (180Ω) minor fault</td>
</tr>
<tr>
<td>Ex e box with glands Specified terminals</td>
<td>GAS BLOCK</td>
</tr>
<tr>
<td>Ex m Ex d Small enclosure if suitable switch available</td>
<td>PROCESSOR</td>
</tr>
<tr>
<td></td>
<td>24V</td>
</tr>
</tbody>
</table>

**Cost**

<table>
<thead>
<tr>
<th>Cost</th>
<th>60</th>
<th>60</th>
<th>160</th>
<th>16</th>
<th>10</th>
<th>20</th>
<th>150 + 985</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>160</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1135</td>
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</table>
Ex n switch loop

<table>
<thead>
<tr>
<th>Hazardous area</th>
<th>Safe area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex e junction box, terminals and glands</td>
<td>GAS BLOCK</td>
</tr>
<tr>
<td>Ex i switch loop</td>
<td>Isolator</td>
</tr>
<tr>
<td>Ex e junction box, terminals and glands</td>
<td></td>
</tr>
</tbody>
</table>

Simple apparatus
Any switch
Suitable for application

Enclosed switch
Type n certified

<table>
<thead>
<tr>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>1095</td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>110 + 985</td>
</tr>
</tbody>
</table>

Total 1095

Ex i switch loop

<table>
<thead>
<tr>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1095</td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>110 + 985</td>
</tr>
</tbody>
</table>

Total 1095

Ex n switch loop
Slide 33
No simple apparatus rules, hence certified switch.
Lower cost interface.

Slide 34
Switch defined by installation drawing; effectively simple apparatus.
Lower cost interface.

Slide 35
Compiled switch cost.
Shows all costs dominated by fixed loop cost and cable cost in particular.
In practical terms very little difference exists between the methods of protection.
US Ex transmitter loop

Ex d transmitter loop
Ex e transmitter loop

Cost

<table>
<thead>
<tr>
<th>Hazardous area</th>
<th>Safe area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex d transmitter and glands</td>
<td>Ex e Thermowell and head</td>
</tr>
<tr>
<td>Ex e junction box, terminals and glands</td>
<td></td>
</tr>
<tr>
<td>GAS BLOCK</td>
<td>PROCESSOR</td>
</tr>
<tr>
<td>150</td>
<td>80</td>
</tr>
<tr>
<td>500</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>800</td>
<td>985</td>
</tr>
<tr>
<td>Total</td>
<td>1785</td>
</tr>
</tbody>
</table>

Ex i transmitter loop

Cost

<table>
<thead>
<tr>
<th>Hazardous area</th>
<th>Safe area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex d transmitter Ex e glands (needs Ex i certification)</td>
<td>Simple apparatus RTD suitable for application</td>
</tr>
<tr>
<td>Ex e junction box, terminals and glands</td>
<td></td>
</tr>
<tr>
<td>GAS BLOCK</td>
<td>Isolator Barrier</td>
</tr>
<tr>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>480</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>670</td>
<td>985</td>
</tr>
<tr>
<td>Total</td>
<td>1655</td>
</tr>
</tbody>
</table>
### Ex n transmitter loop

**Hazardous area**
- Ex d transmitter and glands
- Ex e junction box, terminals and glands

**Safe area**
- Processor

<table>
<thead>
<tr>
<th>Cost</th>
<th>US</th>
<th>Non incendive</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

### US Non incendive transmitter loop

**Hazardous area**
- US Ex transmitter and glands
- Head and Thermowell covered by drawing description

**Safe area**
- Processor

<table>
<thead>
<tr>
<th>Cost</th>
<th>US</th>
<th>Non incendive</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>20</td>
<td>500</td>
</tr>
</tbody>
</table>
Slide 36
Thermowell and head have to be certified, questionable whether this can include elevated temperature? The same transmitter is used regardless of the method of protection. For this exercise the cost remains the same. Premium for conduit extended to all cable runs.

Slide 37
Major change removal of conduit premium

Slide 38
Lower cost thermowell and head and junction box.

Slide 39
Simple apparatus thermowell and head. Increased interface cost. Theoretically transmitter cost could be reduced but it is not.

Slide 40
Certified thermowell and head

Slide 41
Thermowell and head covered by installation drawing.

Slide 42
The costs are dominated by the multicore cable and other fixed cost and the cost of transmitter.

Methods of implementing and recording are changing, partially influenced by “SMART” equipment

Annual Check
Installation is according to documentation
Mechanical damage to equipment and cables
Effectiveness of enclosures and glands
Flameproof gaps?
Isolation of intrinsically-safe circuits?
Cost 60/loop/annum

Inspection
Slides 45 and 46
Collect the information and demonstrate a widening in cost differences.

Example of calculation of Ex d transmitter cost.
Ex d installed cost 1845
Inspection cost 60x10  600
Fault cost
Work permit 50
Gas clearance certificate obtain 100
maintain (x2) 200
Technician cost (x2) 200
Cost per fault 550
Two faults 1100
Cost for ten years 3545

Cost of Repair of Instrument Loop

Slide 44
This shows the cost of gas clearance certificates, which cost money to obtain but require additional costs which double the cost of maintenance.

<table>
<thead>
<tr>
<th>Task</th>
<th>US Ex</th>
<th>Exd</th>
<th>Exn</th>
<th>Exl</th>
<th>Exe</th>
<th>US ni</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permit to work</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Gas Clearance Certificate</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintaining Certificate</td>
<td>200</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technician cost/fault</td>
<td>300</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>650</td>
<td>550</td>
<td>350</td>
<td>150</td>
<td>350</td>
<td>150</td>
</tr>
</tbody>
</table>

Assumptions
a* : 2 x factor due to difficulty with glanding
b* : increment due to difficulty with stoppers
c* : extended repair time

Task US Ex Exd Exn Exl Exe US ni
Ex n 3210 2895 2435 1995 1845 1695 150
Ex e 3005 2685 2335 2155 2065 1815 150
Ex d 3880 3545 3085 2555 2265 2015 150
Ex i 1980 1845 1785 1555 1655 1705 1625
Ex l 1735 1695 1665 1515 1585 1535 150
Ex n 1635 1595 1565 1475 1535 1500 150
Ex e 1625 1585 1555 1465 1525 1500 150
Ex d 1605 1565 1535 1445 1505 1500 150
Ex i 1455 1415 1385 1295 1355 1305 1305
Ex l 1205 1165 1135 1085 1145 1105 1105
Ex n 1105 1065 1035 985 1045 1005 1005

Cost of ten years ownership of switch loop

Cost of ten years ownership of transmitter loop
Copy of Apparatus Certificate plus any installation drawings

System certificate or installation requirements

Evidence of Quality Control
eg BASEEFA Licence

Installation Manual

Notification of any special requirements for maintenance and inspection

If mixed methods of protection are used then particular care is necessary and literature must be good

Supplier?

---

Zone 0  Ex ia only

Zone 1  Ex ia ib d e m

Zone 2  Ex n & above
(Self certification more acceptable)

How definite is the area classification?

If uncertain avoid Type n

Area Classification?

---

Have you got Carbon Disulphide?

| YES | Equipment must be IIC T6  
|     | IS simple apparatus difficult  
|     | Not all IIC Ex d equipment is suitable |
| NO  | Sigh with relief, you can use T4 equipment |

Have you got Acetylene?

| YES | Not all IIC Ex d equipment is suitable  
|     | Has to be checked for particle emission |
| NO  | You can also forget acetylides etc |

Have you got Hydrogen?

| YES | You need IIC equipment  
|     | Ex d not very practicable, may not be available, may need barrier glands, and care with positioning |
| NO  | You can settle for IIB. Relax on Ex d and forget Ex i cable parameters  
If possible specify IIB T4 to give maximum freedom of choice |

Gas and Temperature classification

---
If unspecified will be -20 to +40°C

Ex d e n all prone to low temperature embrittlement

Ex e & n insulation properties temperature sensitive

Ex d cable softening

Approximate Power limits for intrinsically safe apparatus

<table>
<thead>
<tr>
<th></th>
<th>IIC</th>
<th>IIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_0$</td>
<td>30V</td>
<td>42V</td>
</tr>
<tr>
<td>$I_0$</td>
<td>250mA</td>
<td>500mA</td>
</tr>
<tr>
<td>$P_0$</td>
<td>3.0W (1.3W)</td>
<td>5.0W (1.3W)</td>
</tr>
</tbody>
</table>

Maintenance Capability?

- **US Ex**: Stopper boxes makes it difficult
- **Ex d**: Finer points difficult if IIB gas less critical
- **Ex e**: Near perfection essential
- **Ex i**: Not critical if documentation good
- **Ex n**: All things to all men
  - Thank goodness it’s Zone 2
- **US ni**: Good if well specified

Ambient Temperature?

If unspecified will be -20 to +40°C

Ex d e n all prone to low temperature embrittlement

Ex e & n insulation properties temperature sensitive

Ex d cable softening

Power Level?

Approximate Power limits for intrinsically safe apparatus

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Quality control requirements apply to all methods of protection to various levels. In Europe, ATEX requirements prevail. In US, certification authorities have requirements. Can become bureaucratic menace if not restrained.
A dominant cost in these arguments is the fixed multicore cost. This cost is being attacked by the distributed system – multiplexer – fieldbus techniques.

There is a positive movement towards distributed systems as exemplified by the MTL8000 system illustrated.

This introduces a completely new cost discussion.

Some possible variations on the theme of distributed systems