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Static Dissipating Fluoropolymer Lined Piping Systems

Independent Test Reports

Chilworth Technology - 17.02.99

**Zeneca Process Technology
Process Hazards Section - 17.2.99**



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Test Report

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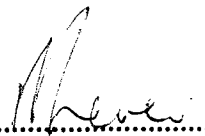
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Contact: Mr C Bullock
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**TEST REPORT FOR
Anti-Static PTFE Tube**

Prepared by



Approved by



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FOR AND ON BEHALF OF CHILWORTH TECHNOLOGY LIMITED

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1. INTRODUCTION

At the request of Corrosion Resistant Products the following parameters have been determined for a sample of Anti- Static PTFE Tube:

- Volume & Surface Resistivity

The results are summarised in Section 2 of this report. A description of the test procedures together with full test results and information on their interpretation is given in the test sections of this report. Chilworth Technology Ltd would be pleased to provide specific advice, including interpretation and application of experimental data. Site visits to discuss operational safety or to perform plant inspections and measurements can be arranged on request. Section 3 provides some background information.

Chilworth Technology's Laboratories are GLP (Good Laboratory Practice) compliant and this study was carried out to the principles of GLP. All original test records are kept in a locked archive for a minimum of 10 years after the date of this report.

The following are the key dates for the work reported here :

- Sample receipt date : 09.12.98
- Start date of the experimental work : 13.01.99
- Completion date of the experimental work : 22.01.99

Note : Any remaining sample material will be stored for 1 month after the issue date of this report and will then be disposed of.

Name and address of client:

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3. BACKGROUND

Every process, reactor, or solids handling operation requires a defined Basis of Safety appropriate to its hazard potential. The objective of any hazard assessment is to provide an acceptable level of safety consistent with the manufacturing, engineering and economic requirements of the process as well as satisfying all applicable regulations.

In defining a Basis of Safety a number of parameters need to be considered. These are:

1. General hazards in the work place.
2. Health toxicological hazards.
3. Hazards associated with equipment and operations not specific to a process, e.g. plant maintenance.
4. Hazards due to chemical reactivity.
5. Operational hazards. That is, hazards that are associated with flammable materials and operations in specific processes or plants.

This report is primarily concerned with point 5, operational hazards.

In order to assess the operational hazards which may arise in a plant it is necessary to have information on the flammability characteristics of any gases, liquids and powders used or encountered. This includes:

1. *Flammability*: does the material support combustion and under what conditions.
2. *Ignition sensitivity*: temperature or energy required for ignition.
3. *Ignition consequences*: rate and type of combustion / flame spread and pressure development during an explosion.

Data on the flammability characteristics of common liquids and gases are readily available in the literature. Information for powders is, however, rarer. This is partly because it is only recently that standard test methods for assessing flammability have been agreed. More importantly, as the physical form, e.g. particle size or moisture content, can markedly affect the flammable characteristics of dusts, it is usually necessary to measure these parameters using a sample of the powder being used.

The presence of a flammable atmosphere or thermally sensitive material does not on its own constitute a hazard. A source of ignition is also required that is capable of igniting the atmosphere.

Ignition sources (excluding electrical equipment) associated with typical process plant operations are summarised below.

(a) Flames and hot surfaces

Heat is the most common form of energy input and sources of heat can directly or indirectly lead to ignition.

Direct ignition of a flammable atmosphere can occur when its temperature exceeds the auto- (or minimum) ignition temperature. The temperature of the atmosphere can be measured and this risk readily quantified.

In powder handling plant, ignition of a flammable atmosphere is likely to be more indirect and be caused by exothermic decomposition of bulk or layer material rising to a smouldering or a fire condition. The decomposition temperature of bulk material and surfaces where layers can form needs to be established and related to the thermal decomposition temperatures of the material.

(b) Friction

Friction can be present in many operations ranging from high speed sustained contact, to single impacts between materials.

Mechanical friction can arise from a malfunction in bearings, binding of moving parts, tramp metal etc., all of which are capable of igniting flammable atmospheres or thermally sensitive materials.

A potent source of ignition is the thermite reaction that can result from impacts involving aluminium, titanium or magnesium and rust.

(c) Static electricity

Static electricity can be generated in virtually all industrial operations. Electrostatic discharges ("sparks") can occur from isolated conductors, personnel, insulating materials (i.e. plastics), liquid or powder surfaces, fine droplet mists, and dust clouds.

(d) Material properties

Certain materials are pyrophoric (e.g. finely divided metals) or have a tendency to self heat or undergo rapid decomposition. Under certain conditions they may ignite themselves or act as an ignition source for any other flammable atmosphere or thermally sensitive component that may be present.

(e) Other sources of hazard

In addition to the above, individual processes may contain sources of ignition specific to the process. An essential part of process definition is the assessment of this possibility. For example in processes involving solid amines, it is important that they do not come into contact with nitrous fumes as an exothermic reaction and then ignition can occur.

Sources of ignition can be categorised as:

- Those external to the specific manufacturing process (e.g. naked flames, welding, electrical equipment etc.)
- Those associated with the plant operations that form part of the manufacturing process.

External ignition sources should always be controlled or eliminated as a consequence of good plant house-keeping, maintenance and associated in-house regulations.

Internal sources can be considered to be those arising from chemical or manufacturing operations. These include for example the generation of static electricity during reactor charging and materials handling, friction during the grinding of powders and the development of exothermic decomposition during drying operations. It should be recognised that in specialist industries (e.g. the explosives industry and in peroxide manufacture) these parameters will need to be supplemented by data obtained using test methods specific to these industries.

A systematic procedure based on those factors outlined above can be used to identify the hazard, assess the risk and define an appropriate Basis of Safety to ensure the process is free from operational hazards.

Together with a knowledge of the process plant and operations, test data as reported here forms an essential part of a hazard or risk assessment procedure and allows a Basis for Safety to be clearly defined, to ensure freedom from fire and explosion.

4. SURFACE RESISTIVITY

4.1 Procedure and results

Test purpose : To examine the surface resistivity of Anti-static PTFE Tubing.

Definition : The surface resistivity of any material is the electrical resistance between opposite sides of a unit square. The dimensions are therefore $\Omega \times L/L$, or Ω . In order to avoid confusing this specific property with resistance, the units are sometimes given as Ω/\square (ohms per square). Surface resistivity is a physical property of the material in question and (in principle) is not dependant on the method of measurement.

Procedure : Surface resistivity is determined by placing a cell, comprising two electrodes, on the surface of the material to be tested. The geometry of the cell is fixed such that a cell constant, c , may be defined. From the units of surface resistivity given above it is clear that c is a dimensionless constant.

The resistance, R , across the cell is measured either directly using a megohmmeter, or by calculation from the measured current when a known potential difference is applied between the electrodes. The surface resistivity of the material is then given by $R \times c$ (Ω).

For many non-metallic materials, the observed resistance depends on the applied potential difference. For this reason the resistivity is determined at more than one energising voltage.

Most materials also adsorb atmospheric water to a lesser or greater extent, which for many materials has a dramatic effect on the surface resistivity. The test is therefore carried out at more than one relative humidity.

Test standard : In general accordance to CECC 00015-I
 Test Apparatus : Surface resistivity cell, BM80 Megger
 Sample : Anti-Static PTFE Tube
 Date of Test : 13.01.99 / 20.01.99
 Operator : P.Bremble

Results:

RH (%)		Temperature (°C)		Surface Resistivity (Ω)	
Outside	Inside	Outside	Inside	Outside	Inside
55	60	18	17	2.7×10^5	1.8×10^5
< 10	< 10	30	35	1.7×10^5	2.5×10^5

4.2 Table of test results for Outside Tube

Test Voltage (V)	Resistance (Ω)
Ambient humidity	
50	2.7×10^5
100	1.9×10^5
250	1.0×10^5
50	1.3×10^5
100	1.0×10^5
250	8.0×10^4
50	1.2×10^5
100	1.0×10^5
250	7.0×10^4
Low relative humidity	
50	1.7×10^5
100	1.3×10^5
250	8.0×10^4
50	1.1×10^5
100	1.0×10^5
250	8.0×10^4
50	1.2×10^5
100	1.0×10^5
250	9.0×10^4

4.3 Table of test results for Inside Tube

Test Voltage (V)	Resistance (Ω)
Ambient humidity	
50	1.7×10^5
100	1.2×10^5
250	1.0×10^5
50	1.8×10^5
100	1.1×10^5
250	1.2×10^5
50	1.3×10^5
100	1.2×10^5
250	1.3×10^5
Low relative humidity	
50	1.6×10^5
100	9.0×10^4
250	9.0×10^4
50	2.5×10^5
100	1.7×10^5
250	1.3×10^5
50	1.4×10^5
100	1.2×10^5
250	1.3×10^5

4.4 Interpretation of results

By the application of a set voltage across a known square of material the resultant current flow can be accurately measured. The electrical resistance can therefore be determined by the following calculation:

$$\frac{V}{I} = R$$

where

V : applied voltage
I : measured current
R : resistance

In the case of Anti-Static PTFE Tube, it was not possible to apply the normal set voltages to the material due to the relatively high conductivity. Therefore, measurements were made directly from a Megger BM10.

By definition a material would no longer be regarded as static dissipative when the surface resistivity is found to be greater than $10^{10} \Omega$.

In the case of the Anti-Static PTFE Tube the material had a surface resistivity of $10^5 \Omega$ and was determined to be static dissipative or antistatic.

5. VOLUME RESISTIVITY

5.1 Procedure and results

Test purpose : To determine the volume resistivity of a plastic in bulk under specified test conditions

Procedure : The material is measured using a test cell consisting of two parallel plane electrodes of 50 mm diameter, 2.9 mm (thickness of tube) apart. A DC voltage is applied between the electrodes and the resistance is measured. Taking the tube and electrode dimensions into account, the volume resistivity is calculated.

In many materials the volume resistivity is dependent on the applied voltage, and therefore at CTL three different voltages are used. The tests are carried out in triplicate and the highest volume resistivity found in any test, is reported as the final result.

Moisture can have a significant effect on the volume resistivity, depending on whether the material holds moisture or not. Tests are therefore carried out in ambient relative humidity (RH) and in dry conditions (RH < 10 %). In the latter case the sample is conditioned at low RH for 24 hours prior to testing.

Test standard : BS 6233 which is in general accordance with BS 5958: Part 1: 1991. Control of undesirable static electricity.

Apparatus : Test electrodes, BM80 Megger

Cell constant : 0.7

Sample : Anti-Static PTFE Tube

Date : 21.01.99

Operator : P.Bremble

Results:

RH (%)	Temperature (°C)	Volume resistivity ρ_v (Ωm)
60	18	2.1×10^4
< 10	32	2.1×10^4

5.2 Table of test results

Test voltage (V)	Measured Resistance (Ω)	Volume resistivity (Ωm)
Ambient relative humidity:		
50	3.0×10^4	2.1×10^4
100	2.0×10^4	1.4×10^4
250	2.0×10^4	1.4×10^4
50	2.0×10^4	1.4×10^4
100	2.0×10^4	1.4×10^4
250	2.0×10^4	1.4×10^4
50	2.0×10^4	1.4×10^4
100	2.0×10^4	1.4×10^4
250	2.0×10^4	1.4×10^4
Low relative humidity:		
50	3.0×10^4	2.1×10^4
100	2.0×10^4	1.4×10^4
250	2.0×10^4	1.4×10^4
50	2.0×10^4	1.4×10^4
100	2.0×10^4	1.4×10^4
250	2.0×10^4	1.4×10^4
50	2.0×10^4	1.4×10^4
100	2.0×10^4	1.4×10^4
250	1.0×10^4	7.0×10^3

5.3 Interpretation of results

The volume resistivity assesses the materials ability to retain static electricity, and how quickly charge can be dissipated through the material.

The resistivity required to prevent the retention of charge and the production of undesirable effects depends on the nature of the effect, e.g. whether it is dust contamination or ignition risk, and on the rate of accumulation of charge on the material. Surface and volume resistivities below about $10^8 \Omega$ and $10^6 \Omega\text{m}$ respectively, are generally regarded as producing no undesirable effects except possibly in relation to explosives. In many applications, however, surface and / or volume resistivities below about $10^{11} \Omega$ and $10^{10} \Omega\text{m}$ respectively, may be sufficient under normal ambient conditions.

In assessing the electrostatic hazard, it is important to realise that incendive electrostatic discharges can occur from a variety of sources, including plant and people. To eliminate the electrostatic hazards, all potential sources of electrostatic discharges must be considered. Chilworth Technology can advise on the measures to take in a particular situation.



Zeneca Process Technology

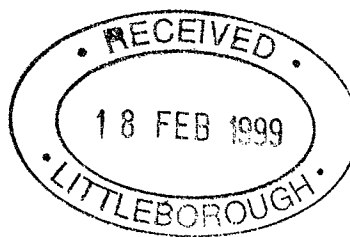
Process Hazards Section

Test Report

ZENECA

Process Hazards Section
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PTD/HPS/2.23/98/241/1

0161-721

1970/1605

17 February, 1999

Dear Cliff,

FIRE AND EXPLOSION HAZARDS : RESISTIVITY OF PTFE SHEET

Thanks for coming in to see both myself and Heather on Wednesday, it was good to meet you and talk over the results on the PTFE sheet.

As agreed we have carried out further resistivity tests on the original test sample, (HT98/241) using various methods. The results are listed in the attached table and graph. In summary, I think two points have emerged. Firstly, the measured resistance is very dependent on electrode contact; results with applied compression and electrolyte are much lower than those without. (Table 1) Secondly, test potential has a direct influence on the measured resistance. The lower the voltage the higher the measured resistance! A non-ohmic system seems to be present. (Figure 1)

Tests on the material removed from the pipe section gave results lower than the original test piece, of the order $10^5 - 10^6 \Omega.m$, but again this is dependent on test potential.

In conclusion, we can confirm that both the tested materials meet the Zeneca specification for anti-static properties. In addition, it is our opinion that these materials conform to the requirements of BS2782 Part 2, Method 230A "Methods of Testing Plastics - Determination of Volume Resistivity"

If you have any further queries please do not hesitate to contact either Heather or myself on the above telephone numbers.

Yours sincerely,


Mike Bailey

Table 1

Test Method	Measured Resistance (Ω)	Volume Resistivity ($\Omega.m$)
1	$2 * 10^6$	$1.9 * 10^7$
2	$5 * 10^5$	$4.7 * 10^6$
3	$2 * 10^7$	$1.9 * 10^8$
4	$8 * 10^5$	$7.6 * 10^6$

Method (1) Two brass plate electrodes fully covering each surface, no compression applied, no electrolyte used.

Method (2) As method 1, but with applied compression.

Method (3) Close contact aluminium foil and electrolyte were used between the test sample and the brass plate electrodes.

Method (4) As method 3, but with compression.

Figure 1

