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Basic environmental testing procedures Part 2 : Tests Guidance to Test Kd : Hydrogen sulphide test for contacts and connections

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

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Basic environmental testing procedures
Part 2: Tests
Guidance to test Kd: Hydrogen sulphide test for contacts and connections

Foreword for Japanese Industrial Standard

This Japanese Industrial Standard has been prepared based on the first edition issued in 1982 of "**IEC 68-2-46** Basic environmental testing procedures Part 2: Tests—Guidance to Test Kd: Hydrogen sulphide test for contacts and connections" without changing the technical contents.

Portions underlined with dots and side lines are not specified in the original International Standard.

1. Introduction

Satisfactory performance during the desired lifetime of contacts and connections depends on many parameters, some of them determined by their design (type, materials, forces, etc.) and others by the environment in which they have to function. Concerning the effects of the environment, special attention must be paid to the polluting substances contained—usually in very small amounts—in the atmosphere.

Silver and some of its alloys are peculiarly susceptible to tarnishing by the minute quantities of hydrogen sulphide that occur in many environments. The tarnish product is dark in colour and consists largely of β-silver sulphide.

Separable electrical connections employing these metals as contact materials may therefore suffer from increased contact resistance and contact noise as a result.

2. Hydrogen sulphide in the atmosphere

Hydrogen sulphide is evolved by bacterial reduction of sulphates in vegetation, soil, stagnant water and animal waste. In the atmosphere it is readily oxidized to sulphur dioxide, which is brought to the ground by rain. Where the soil is aerobic, certain bacteria turn the sulphur dioxide to sulphates. When or where rotting organic matter generates anaerobic conditions, sulphate reducing bacteria complete the cycle and turn the sulphate to hydrogen sulphide, which is the principal natural sulphur input in the atmosphere. It is therefore a widespread pollutant in air.

Sulphur dioxide will accumulate in the atmosphere when it is not rinsed by rain. In urban areas burning of fossil fuels emits sulphur dioxide into the atmosphere. The content can be 10 times to 1 000 times that of hydrogen sulphide and becomes the dominant cause of corrosion. In equal concentration, hydrogen sulphide is the more corrosive of the two, particularly on silver and copper. (See **JIS C 0090**–1993 Basic environmental testing procedures Part 2 : Tests Test Kc : Sulphur dioxide test for contacts and connections.)

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Informative reference: **JIS C 0090**-1993 is identical to **IEC 68-2-42**: 1982 Basic environmental testing procedures Part 2: Tests Test Kc: Sulphur diode test for contacts and connections.

Although the major input to the sulphur cycle is by hydrogen sulphide through natural processes, industrial processes also play a part. Oil refineries, chemical plants and gas works are all possible sources. Atmospheric concentrations of 1 ppb to 30 ppb (parts in 10^9 by volume) are commonly reported. At many sites peak values exceed this, and much higher concentrations are found close to sources. Table I illustrates a typical statistical distribution of measurements of hydrogen sulphide concentration. Table II lists representative concentrations at a range of sites. These levels are sufficient to account for the natural tarnishing of silver. Other sulphurous pollutants are much less important.

Sulphur dioxide has little effect on silver unless the concentration and humidity are high, and then it produces a tarnish product that is rarely found in practice. The two commonest organic sulphurous pollutants: methyl mercaptan and carbon disulphide do not tarnish silver at all. Some organic sulphur derivatives do tarnish silver, as does elemental sulphur vapour, but these materials probably occur only in a small minority of environments.

3. Object and scope of the test

3.1 *Types of contacts and connections*

As this test is specifically intended for certain types of contacts and connections (other than those of the welded or soldered type), a short description of these types of contacts and connections is considered to be useful.

Contacts and connections may be divided into two types and could be described as permanent or temporary. In both cases, metal surfaces are held together by an external force.

In the case of permanent connections, the force is very great and will usually cause permanent deformation of the metals and it is possible that a form of local welding takes place. Such connections are not intended to be made and broken during their lifetime. Examples of permanent connections are crimp and wrap joints.

With temporary connections, the force holding the metals in contact is by comparison light and they are of course designed to be made and broken possibly very many times during their lifetime. Examples of temporary connections are: connectors, switches and relays. In temporary connections the areas of metal which make contact with each other are in some cases referred to as contacts.

The contacts or contact areas in temporary connections will be made of various metals according to duty and application. Most metals—with the exception of precious metals—suffer from atmospheric corrosion. When contact materials corrode, contact resistance increases. The extensive use of precious metal contacts would be costly, so it is common in many applications to use precious metal alloys or coatings of precious metal or alloys over base metals for contact materials.

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In the case of permanent joints, it is not normal to use precious metals and some general corrosion of external surfaces by hydrogen sulphide must be expected. But, in a properly designed and made crimp or wire wrap joint, corrosion does not occur between the contact surfaces due to the cold weld and high pressure. However, in joints that are poorly made or weakened as a result of thermal cycling, corrosive gas will penetrate into those contact areas with a resultant increase in contact resistance.

3.2 *Object of the test*

The test has been devised to assess the consequence of tarnishing of silver and some of its alloys. It has been largely validated by laboratory and field tests on silver, though limited tests have also been carried out on components with contacts of some silver alloys.

When the same tarnish test is appropriate to test specimens containing different contact materials, then the test conditions may give rise to different accelerations (see Clause 5), and considerable experience and experimentation may be required to assess relative results. Contact alloys of silver and palladium represent a case where the test is appropriate but where such care is required.

When the test is used for contacts and connections involving silver alloys and silver in conjunction with other materials the test is expected to give more realistic results for those involving silver together with a more precious metal than it will for silver alloys (or structures) involving significant quantities of base metals. The following cases are given by way of example:

- Gold contacts are largely unaffected by the test.
- Contacts involving gold layers over silver or gold contacts in the close proximity of silver will be affected owing to the phenomena of creeping silver sulphide. Both these effects are true reflections of field behaviour.
- Copper and alloys containing a high percentage of copper (such as phosphor bronze or brass) are heavily tarnished in the test atmosphere owing to the formation of copper sulphides. However, this type of tarnishing rarely predominates in practice, where oxide formation inhibits sulphide growth. Hence the test is inappropriate in these cases, if the tarnishing behaviour is required to resemble that occurring naturally.

4. Parameters of the test

This test is for contacts and connections primarily made of silver and silver alloys (see Clause 3), and the criteria of success or failure adopted is that of contact resistance. The test conditions must therefore produce a tarnish layer whose effect on contact resistance is similar to that of naturally grown layers. At the same time the test should accelerate tarnish film growth. Unfortunately, these two requirements tend to be conflicting, since rapidly grown tarnish layers tend to be softer and less adherent than those grown naturally. A compromise must be struck between acceleration (achieved by increasing pollutant concentration and humidity), and realistic contact resistance behaviour.

The present test aims to use the highest hydrogen sulphide concentration and relative humidity that is compatible with realistic contact resistance behaviour.

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