Section 7

Materials Inspection

1 General

One of the duties of the Visual/Welding Inspector is to carry out materials inspection and there are a number of situations where the inspector will be required to carry out materials inspection:

- At the plate or pipe mill.
- During fabrication or construction of the material.
- After installation of material, usually during a planned maintenance programme, outage or shutdown.

A wide range of materials are available that can be used in fabrication and welding. These include, but are not limited to:

- Steels
- Stainless steels
- Aluminium and its alloys
- Nickel and its alloys
- Copper and its alloys
- Titanium and its alloys
- Cast iron

These materials are all widely used in fabrication, welding and construction to meet the requirements of a diverse range of applications and industry sectors.

There are three essential aspects to material inspection that the Inspector should consider:

1 Material type and weldability
2 Material traceability
3 Material condition and dimensions.

2 Material Types and Weldability

A Welding Inspector must be able to understand and interpret the material designation in order to check compliance with relevant normative documents. For example materials standards such as BS EN, API, ASTM, the welding procedure specification (WPS), the purchase order, fabrication drawings, the quality plan/the contract specification and client requirements.

A commonly used material standard for steel designation is **BS EN 10025 – Hot rolled products of non-alloy structural steels.**

A typical steel designation to this standard, S355J2G3, would be classified as follows:

S Structural steel
355 Minimum yield strength: N/mm² at t ≤ 16mm
J2 Longitudinal Charpy, 27Joules 6-20°C
G3 Normalised or normalised rolled

In terms of material type and weldability, commonly used materials and most alloys of these materials can be fusion welded using various welding processes, in a wide range of thickness, and, where applicable, diameters.

Reference to other standards such as ISO 15608 Welding - *Guidelines for a metallic material grouping system*, steel producer and welding consumable data books can also provide the Inspector with guidance on the suitability of a material and consumable type for a given application.

3 Alloying Elements and Their Effects

Iron	Fe	
Carbon	C	Strength
Manganese	Mn	Toughness
Silicon	Si	< 0.3% deoxidiser
Aluminium	Al	Grain refiner, <0.008% deoxidiser + toughness
Chromium	Cr	Corrosion resistance
Molybdenum	Mo	1% is for creep resistance
Vanadium	V	Strength
Nickel	Ni	Low temperature applications
Copper	Cu	Used for weathering steels (Corten)
Sulphur	S	Residual element (can cause hot shortness)
Phosphorus	P	Residual element
Titanium	Ti	Grain refiner, used as a micro-alloying element (strength and toughness)
Niobium	Nb	Grain refiner, used as a micro-alloying element (strength and toughness)

4 Material Traceability

Traceability is defined as 'the ability to trace the history, application or location of that which is under consideration.' In the case of a welded product, traceability may require the inspector to consider the:

- Origin of the materials – both parent and filler material.
- Processing history – for example before or after PWHT.
- Location of the product – this would usually refer to a specific part or sub-assembly.

In order to trace the history of the material, reference to the inspection documents must be made. *BS EN 10204 Metallic products – Types of inspection documents* is the standard, which provides guidance on these types of document. Under BS EN 10204 inspection documents fall into two types:

a) Non-specific inspection

Inspection carried out by the manufacturer in accordance with his own procedures to assess whether products defined by the same product specification and made by the same manufacturing process, are in compliance with the requirements of the order.

Type 2.1 are documents in which the manufacturer declares that the products supplied are in compliance with the requirements of the order **without inclusion of test results**.

Type 2.2 are documents in which the manufacturer declares that the products supplied are in compliance with the requirements of the order and in which **test results based on non-specific inspection are supplied.**

b) Specific inspection

Inspection carried out, before delivery, according to the product specification, on the products to be supplied or on test units of which the products supplied are part, in order to verify that these products are in compliance with the requirements of the order.

Type 3.1 are documents in which the manufacturer declares that the products supplied are in compliance with the requirements of the order and in which **test results are supplied.**

Type 3.2 are documents prepared by both the manufacturer's authorised inspection representative independent of the manufacturing department, and either the purchaser's authorised representative or the inspector designated by the official regulations, and in which they declare that the products supplied **are in compliance with the requirements of the order and in which test results are supplied**.

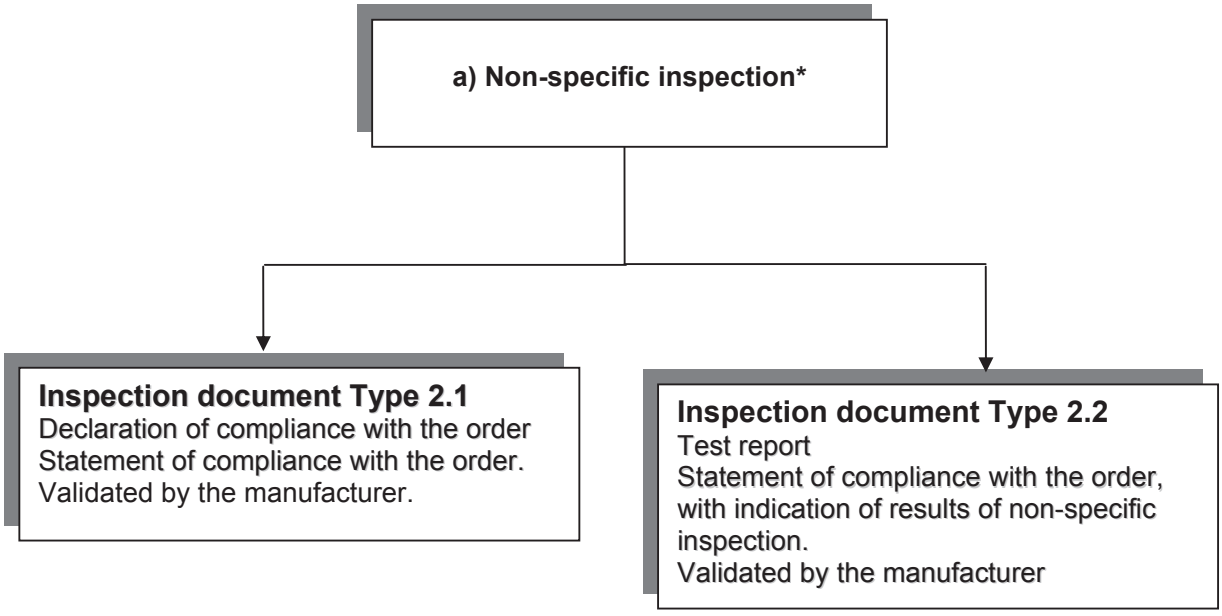
Application or location of a particular material can be carried out through a review of the Welding Procedure Specification (WPS), the fabrication drawings, the quality plan or by physical inspection of the material at the point of use.

In certain circumstances the inspector may have to witness the transfer of cast numbers from the original plate to pieces to be used in production.

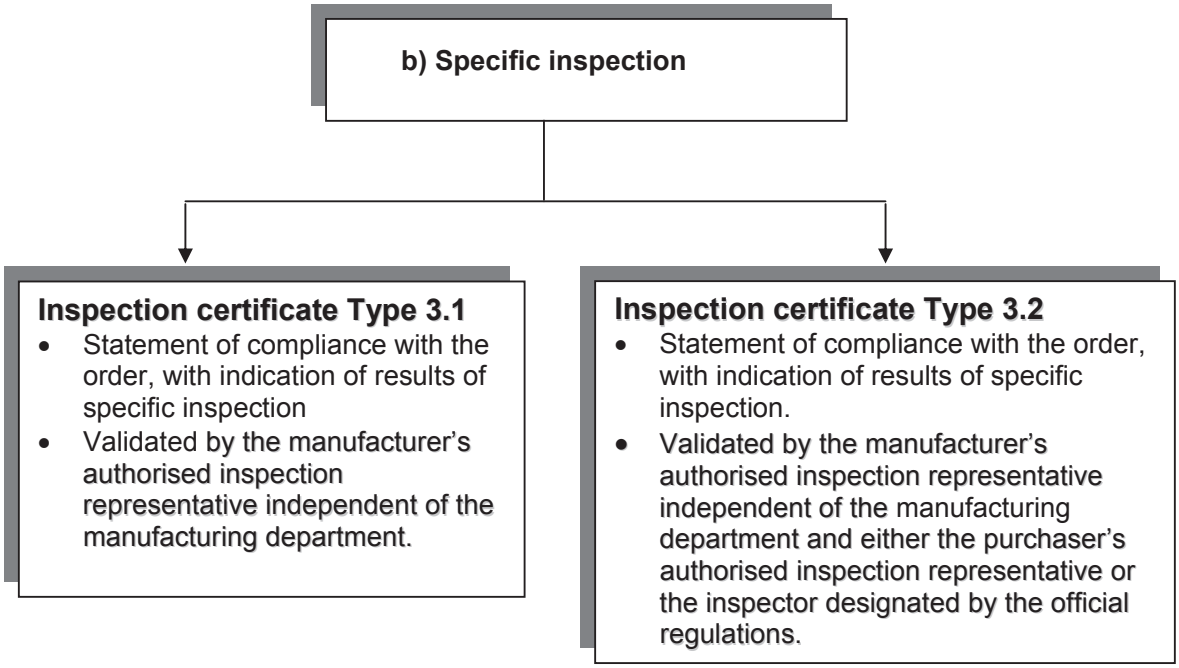
On pipeline work it is a requirement that the inspector records all the relevant information for each piece of linepipe. On large diameter pipes this information is usually stencilled on the inside of the pipe. On smaller diameter pipes the information may be stencilled along the outside of the pipe.

BS EN 10204: Metallic materials

Types of inspection documents summary



a) Non-specific inspection may be replaced by specific inspection if specified in the material standard or the order.



b) Quality management system of the material manufacturer certified by a competent body established within the community and having undergone a specific assessment for materials

5 Material Condition and Dimensions

The condition of the material could have an adverse effect on the service life of the component; it is therefore an important inspection point. The points for inspection must include:

- General inspection.
- Visible imperfections.
- Dimensions.
- Surface condition.

General inspection

This type of inspection takes account of storage conditions, methods of handling, the number of plates or pipes and distortion tolerances.

Visible imperfections

Typical visible imperfections are usually attributable to the manufacturing process and include cold laps, which break the surface or laminations if they appear at the edge of the plate. For laminations, which may be present in the body of the material, ultrasonic testing using a compression probe may be required.

Cold lap

Plate lamination

Dimensions

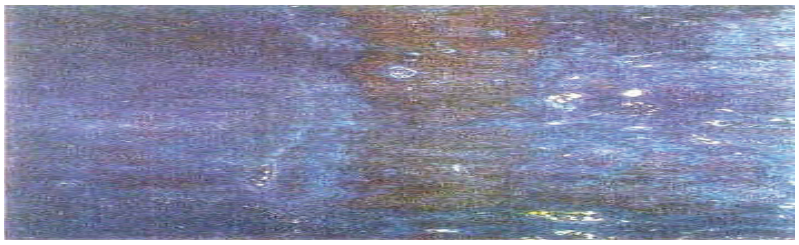
For plates this would include length, width and thickness.

For pipes, this would not only include length and wall thickness, but would also cover inspection of diameter and ovality. At this stage of the inspection the material cast or heat number may also be recorded for validation against the material certificate.

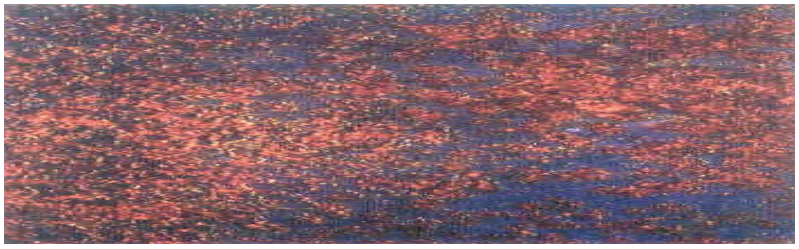
Surface condition

The surface condition of the material is important, it must not show excessive mill scale or rust, be badly pitted, or have unacceptable mechanical damage.

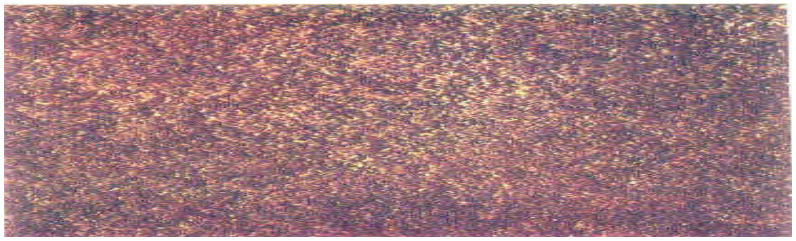
There are four grades of rusting which the inspector may have to consider:



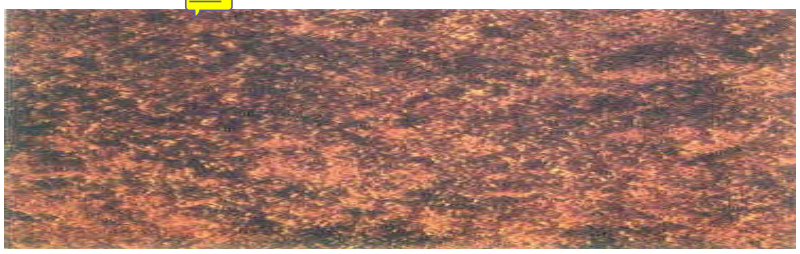
Rust Grade A: Steel surface largely covered with adherent mill scale with little or no rust.



Rust Grade B: Steel surface, which has begun to rust, and from which mill scale has begun to flake.



Rust Grade C: Steel surface on which the mill scale has rusted away or from which it can be scrapped. Slight pitting visible under normal vision.



Rust Grade D: Steel surface on which mill scale has rusted away. General pitting visible under normal vision.

6 Summary

Material inspection is an important part of the inspector's duties and an understanding of the documentation involved is the key to success.

Material inspection must be approached in a logical and precise manner if material verification and traceability are to be achieved. This can be difficult if the material is not readily accessible, access may have to be provided, safety precautions observed and authorisation obtained before material inspection can be carried out. Reference to the quality plan should identify the level of inspection required and the point at which inspection takes place. Reference to a fabrication drawing should provide information on the type and location of the material.

If material type cannot be determined from the inspection documents available, or if the inspection document is missing, other methods of identifying the material may need to be used.

These methods may include but are not limited to: spark test, spectroscopic analysis, chemical analysis, scleroscope hardness test, etc. These types of tests are normally conducted by an approved test house, but sometimes on site, and the inspector may be required to witness these tests in order to verify compliance with the purchase order or appropriate standard(s).

** EN ISO 9000 Quality management systems – Fundamentals and vocabulary*