Application of Welding Standards in Hong Kong

S. K. Babu
Laboratory Manager - Foundation Techniques Ltd

Introduction:

This paper summarizes the current welding standards practiced in Hong Kong & also outlines the difference between the obsolete standards and current European or ISO standards.

Since 1988 a new series of 'mandatory' European standards (EN = Europaischen Normen) has been created, to replace national standards, such as BS, DIN, SS and NF, throughout 18 countries of Western Europe. EN are a part of the 'Single Market' legislation, designed to give equal opportunities for firms to compete throughout Europe, by harmonizing the technical requirements between countries. The national standards bodies, of which BSI is one, are required to officially withdraw their national standards, when an EN is created with the same scope of application.

Consistent pattern of Standards: The aim is to produce a logical, common pattern, in which items are standardized in one document only, reference being made to this document from other standards. For example, tensile testing methods are standardized in a different document to material property values, and dimensional tolerances in other separate standards. Thus, changed requirements need only to be written into one document.

The Changes are outlined in this paper, which include the method of welding, method of inspection, qualifying welders, welding procedures, the paper only outlines the elements which had major changes & which might affect the end product.

Welding Standard:

The common welding standard adopted in Hong Kong for the structural welding is the well known BS 5135:1984, which is still being used in many projects. It is recommended to adopt the current standard to merge with the global changes. The current welding standard is the BS EN 1011-1:1998 & BS EN 1011-2:2001, whereas part 1 is the general guidelines and part 2 is for the arc welding of ferritic steels. As Steels produced to European standard are already in use in Hong Kong, the new welding standard shall be straightly adopted. The BS 5135 can only be used to weld carbon & carbon manganese steels up to a carbon equivalent of 0.54, whereas EN 1011 can be used for welding all metallic materials

The contractor performing the welding shall have a quality system for welding, which shall follow appropriate parts of EN 729; this makes a unique quality system to have a uniform welding quality
The one of the key difference between BS 5135 & EN 1011 is the BS 5135 uses the concept of Arc Energy whereas EN 1011 uses the concept of Heat Input. Heat input is calculated from the weld travel speed. When weaving with manual metal arc welding, the weave width should be restricted to three times the diameter of the core rod.

The delayed testing period recommended in BS 5135 is 48hours, whereas in EN 1011 it is requires to have a period of at least 16 hours before the final inspection is made, The period used shall be stated in the inspection records (possible in a final post visual inspection record).

The guidance of avoiding hydrogen cracking is more detailed in new standard

The guidance of avoiding lamellar tearing is also more detailed in the new standard.
Lamellar tearing is a parent metal phenomenon, which occurs mainly in plate material. The risk of cracking is influenced by two main factors

- Plate susceptibility
- Strain across the joint

Table 1: Comparison of Preheating Levels for various thicknesses for various grade of steel for both standards

Grade of Steel & Combined thickness	**BS 5135 Preheat**	**BS EN 1011 Preheat**
50 A/B or 55C or S355 (85 mm thick)	50° C (graph e)	50° C (graph C2 d)
50 A/B or 55C or S355 (100 mm thick)	75-100° C (graph e)	75-100° C (graph C2 d)
50 A/B or 55C or S460M (120mm thick)	75-100° C (graph e)	75-100° C (graph C2 d)

Note: Hydrogen Content assumed H 5-10 Electrodes - Scale C, Arc Energy: Minimum 2kJ/mm or Heat Input: 1.6kJ/mm; Carbon Equivalent: 0.45. Combined thickness is the total thickness of joining members;

Typical examples of combined thickness are given below

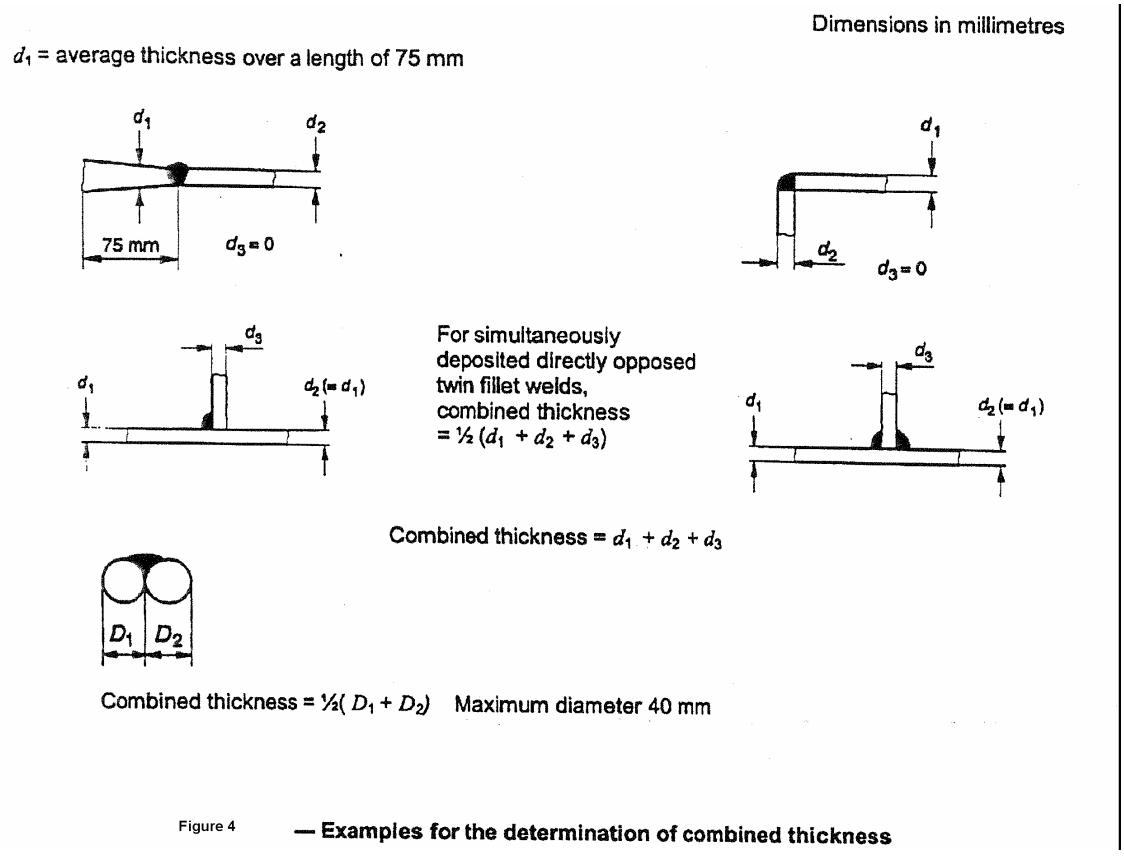


Figure 4 — **Examples for the determination of combined thickness**

Examples of Improved weld joint design to avoid lamellar tearing

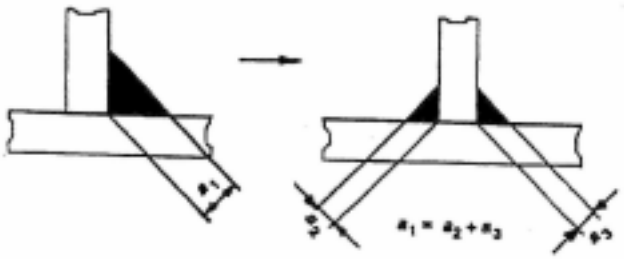


Figure 1: Reduction of sensitivity to Lamellar tearing by enlarging the fusion face

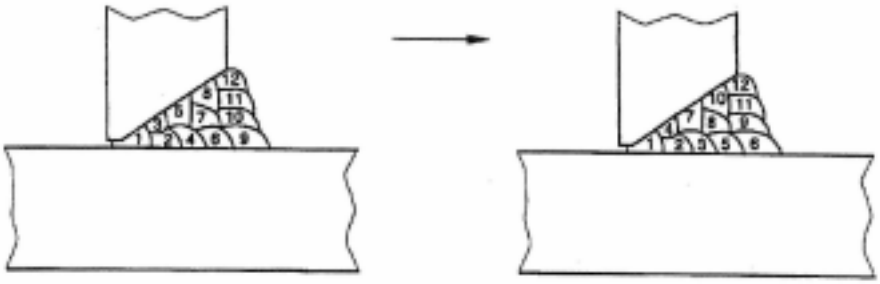
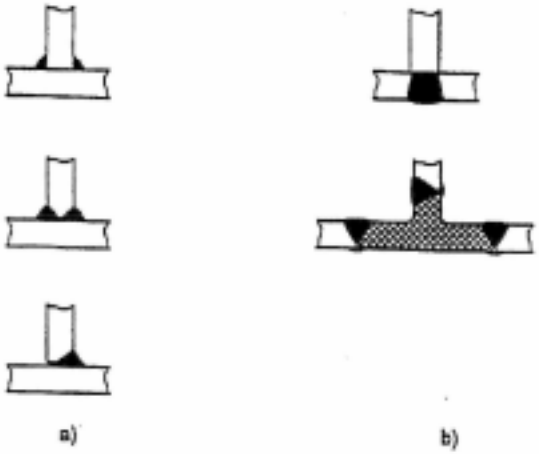


Figure 2: Reduction of sensitivity to Lamellar tearing by layering the welding sequence



Key

a) Sensitive
b) Not sensitive

Figure 3: Reduction of sensitivity to Lamellar tearing by welding the full thickness of the plate

From the comparison table1 for preheating levels, it is to be understood following both the standards result in the same preheating temperature.

Welding Acceptance Criteria:

The Weld acceptance criteria used widely is the Table 18 & 19 of the BS 5135:1984, In the EN 1011 there is no recommendation given on acceptance criteria, it has left to the application standard. So when there is no application standard exist the newly published acceptance criteria for welds which is the BS EN ISO 5817: 2003 could be used, The ISO

5817 covers most of the imperfections occurred during welding and provide the acceptance classification as B, C & D where B corresponds to the stringent requirement of the finished welds

A Comparison table below was made prepared to compare the quality level of BS 5135:1984 & the quality level of BS EN ISO 5817 for equivalence

Table 2: Butt weld Comparison Table

Imperfection Designation	**Limits of Imperfection (stringent)**		**Limits of Imperfection (Intermediate)**	
	BS 5135 (A)	**ISO 5817 (B)**	**BS 5135 (B)**	**ISO 5817 (C)**
Cracks	Not permitted	Not permitted	Not permitted	Not permitted
Lack of fusion	Not permitted	Not permitted	For t≤20mm:L≤10mm H≤2mm For t>20mm;L≤15mm H≤2mm	Not permitted
Lack of Root Penetration	Not permitted	Not permitted	For t≤20mm:L≤10mm H≤2mm For t>20mm;L≤15mm H≤2mm	Not permitted
Individual slag Inclusions	Based on Length and width of defect	H ≤ 0.2 t ≤ 2	Based on Length and width of defect	H ≤ 0.3 t ≤ 3
Gas Pore (Maximum dimension)	D ≤ 2mm	D ≤ 0.2t ≤ 3mm	D ≤ 2.5mm	D ≤ 0.2t ≤ 4mm
Gas Pore Area	≤ 2%	≤ 2 %	≤ 3%	≤ 3%
Under Cut for thickness greater than 3mm	H ≤ 0.5mm	H ≤ 0.05 t ≤ 0.5	H ≤ 0.5mm	H ≤ 0.1 t ≤ 0.5
t - weld thickness; H- Height of the defect; D-Diameter of the Imperfection				

Upon comparison ISO 5817 **Level B** shall be used as a replacement to **Category A** of BS 5135 & **Level C** shall be used as a replacement to **Category B** of BS 5135.

Qualifying Welders

The Welder qualification standard has changed from **BS4871: 1 to BS EN 287-1:2004**
The welders working with the new EN welding standard shall be qualified to BSEN287-1

The major differences between these standards are outlined below

Test Piece:
The test piece for a butt welded plate for BS 4871 shall be a minimum of 225mm in length and 100mm in width, whereas in EN 287-1:2004 the length is increased to 300mm and width is increased to 125mm, the same applies for the pipe.

Testing of butt welds for qualification:
The tests in BS 4871 includes visual, Radiography or Ultrasonic and destructive test (Macro examination and Bend test), whereas in EN 287 visual examination is mandatory and either Non destructive test or Destructive test can be chosen, this makes the welders to get qualified in a short period provided they meet the Acceptance standard which is the ISO 5817 quality level B.
The Bend test angle is increased from 90 degree to 180 degree.

Range of Approval

- There are some minor changes in the range of approval for thickness
- Butt joint in pipe shall be approved for plate as said in BS 4871 but EN permits the same with restriction in the diameter of the pipe & welding position
- Weld metal grouping follows the PD CR ISO 15608

Qualifying Welding Procedure

The manufacturer in accordance with EN ISO 15609-1 shall prepare the welding procedure specification for arc welding. An inspection body shall approve the procedure by conducting welding procedure qualification test.
The test will be performed on a representative sample in accordance with EN ISO 15614-1, which supersedes EN 288, & BS4870
The grouping of material is changed in the new standard compared with BS 4870
The bend test angle is increased from 120° to 180°
The Range of approval includes Heat Input
The Range of thickness approval is different from BS 4870 & classified as single run and multi run
The Acceptance criteria follow the BS EN ISO 5817, Level B

Non-Destructive Testing Methods

The Table below directly correlates the current testing standard for non-destructive testing and highlights the major changes, which shall be taken care while following the full set of standards.

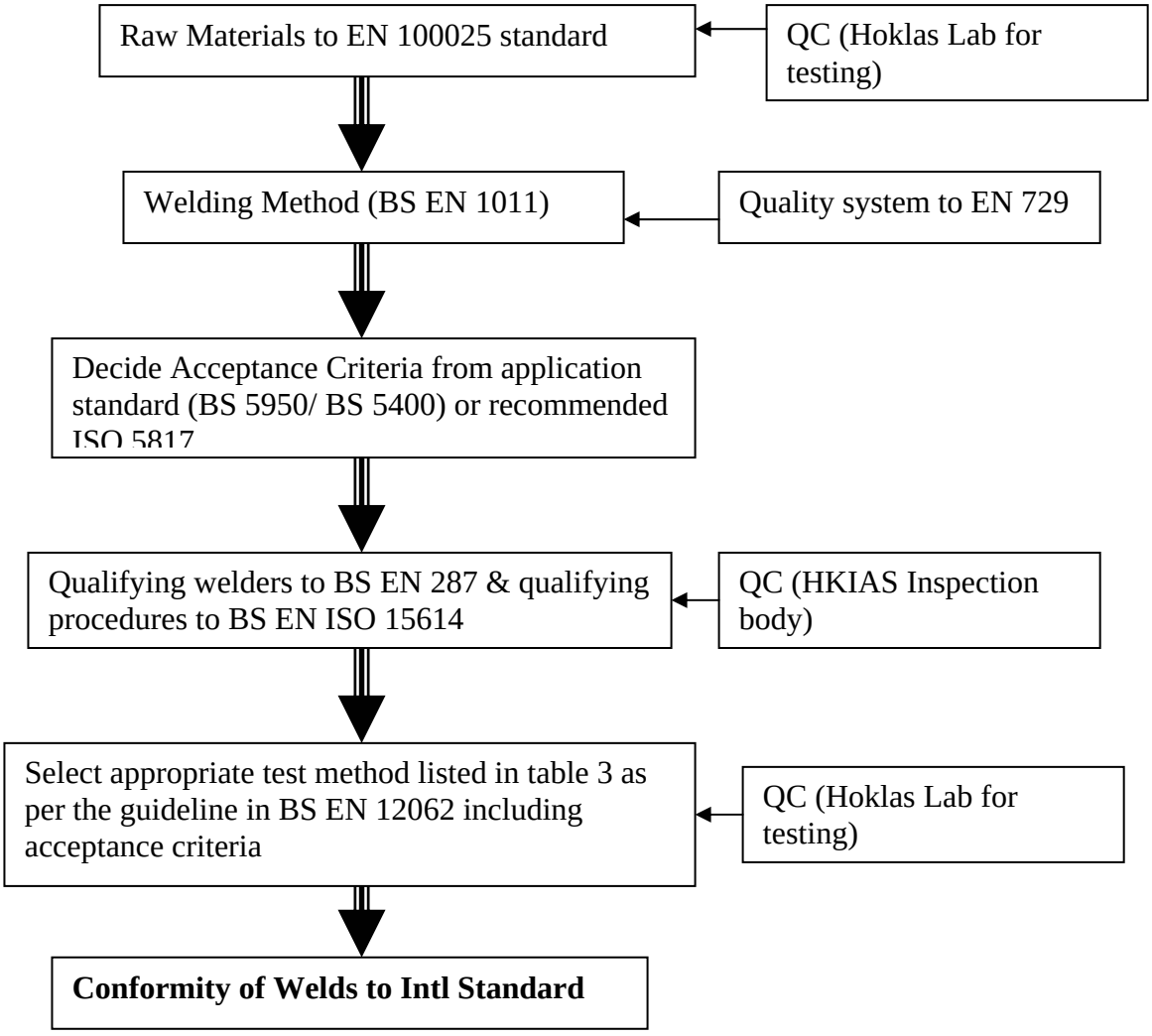
Table 3 - NDT Standards

Test Method	**Old Obsolete Standard**	**Current Standard & Key issues**
Visual Testing	BS 5289:1976	BS EN 970:1997 (No major changes) Vision requirements spelled out
Magnetic Particle Testing	BS 6072:1981(86)	BSENISO 9934-1:2001 Personnel qualification to EN 473. BSEN 1290:1998 (Specifically for welds)
Dye Penetrant Testing	BS 6443:1984 Minimum penetration time is 10 minutes UV irradiance 5 W/m2	BS EN 571-1:1997 Personnel qualification requirements are spelled out, penetration time is from 5min to 60 min UV irradiance 10 W/m2
Ultrasonic Testing	BS 3923:1986 6mm - 150mm thick PCN Level II operator Recording of defects based on DAC or 50% DAC. Echo pattern identification & interpretation with application standards	BS EN 1714:1998 Greater than 8mm thick EN 473 or equivalent Recording of defects based on 80%DAC or 50% DAC Amplitude & length of defects plays key role in rejection using EN 1712.
Radiographic Testing	BS 2600:1: 1983 & part 2 1973 2mm - 200mm	BS EN 1435:1997 Method of calculating SFD is different Recommends various sources for different thicknesses. Optical density requirements are varied. IQI types are changed.

The Table lists the major changes to be noted while using the new standards, personnel performing NDT is one of the key issue to be noted, while discussing the acceptance criteria in previous page, it is to be noted each NDT method got his own merits and demerits, certain defects can be identified in one method and other can't. It is not accurate to estimate the size of the porosity exactly by a ultrasonic method as required straightly by BS EN 25817, that is the reason each test method comes with his own acceptance criteria as detailed in BSEN 12062, decision makers or clients need to understand this & outline the appropriate acceptance criteria for individual test method. For example If the end user selected BS EN 25817:1992 Level B for all his butt welds, and he decided to inspect using Radiography then the corresponding acceptance criteria is BS EN 12517 Level I, If he/she selects UT then the corresponding acceptance criteria is BS EN 1712 Level 2, If he/she selects MT then the acceptance criteria is BS EN 1291 Level 2X.

Detailed information on selecting appropriate NDT Method and equivalent acceptance criteria is spelled out clearly in BS EN 12062:1998.

Flow Chart on Application of Welding Standards



Conclusion:

The Changes in the standard doesn't much affect the welding method including preheating process, but there are stringent requirements in examining the final welded specimens for

accepting their quality. The defect limits have been reduced & inspection methods have been adopted in a more practical approach. It is strongly recommended to follow the complete set of the European standards from raw material to process to product acceptance which avoid cross over of standards & to gain international equivalence in the welding field.