

The exploration to the case of X-ray detection of the vertical angle Weld

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Abstract :

To irradiate upright intersection pipe welds with x-rays, the base metal on both sides of the seam meet in a miter joint, the ray beam and the surface of the detected region is not vertical. As extending from the welding centerline to the outside of the base metal, the ray beam casts more obliquely. In addition, the certain difference in the thickness between the supporting pipe's wall and its branch pipe's wall makes the thickness difference in the effectively detected region being irradiated obviously increased. The greater the thickness difference is , the harder to obtain the quality sensitivity and the film density which meet the standard requirements in the effectively detected region at the same time .This paper presented an acceptable method on subdivision, radiographic thickness、 radiographic mode and exposal parameters by analysis and experiment of the X-ray inspection on upright intersection pipe welds. The experiment results validated that this method could get better imagery quality, and the density difference of the film valid area and image sensitivity could satisfy requirement on JB/ T 4730 —2005 《Nondestructive Testing of Pressure Equipments》 .

Keywords: upright intersection pipe welds, thickness difference, X-ray inspection

1. Preface

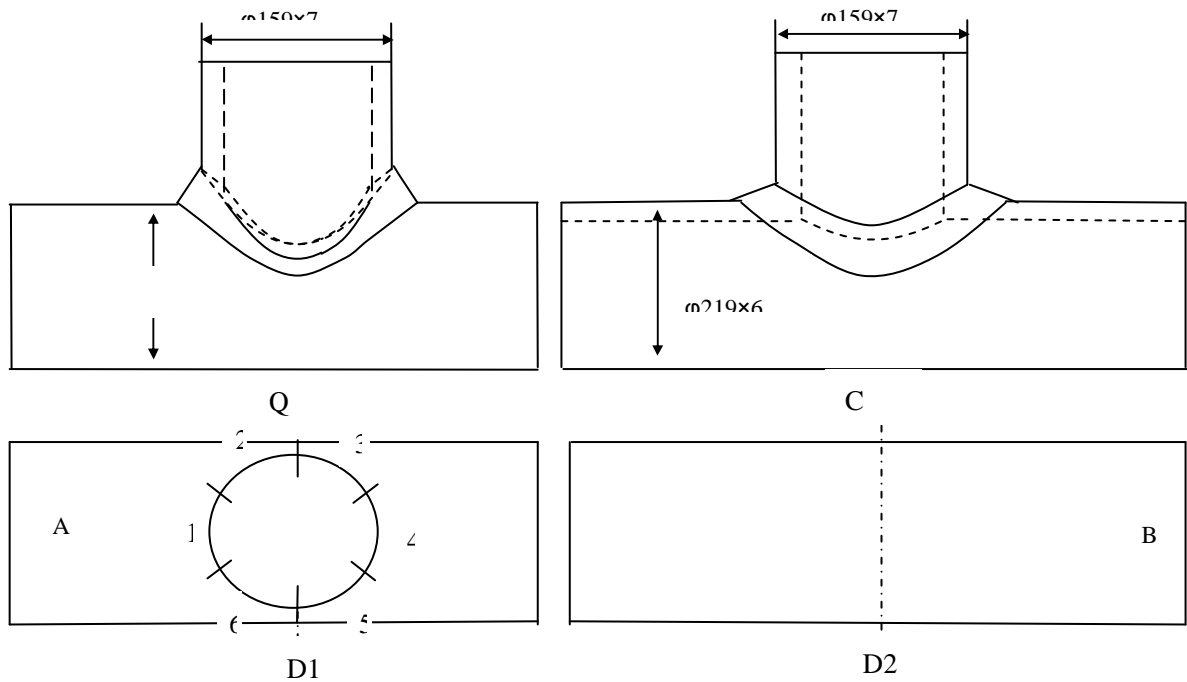


Figure 1 the section's sketch map to place the film for the type of rode, type of inserted upright intersection pipe welds

A Nondestructive Testing Project in my units, according to the design request, Irradiate the pipe welds totally with the X-ray. Basis the actual circumference , we made a $\phi 219 \times 6$ (mm) and a $\phi 159 \times 7$ (mm) vertical and connective simulation specimen: One is the type of rode specimen, its number is Q; the other one is the type of inserted specimen, its number is C, shown by the diagram above.

2. The subsections on the place irradiated of the upright intersection pipe weld

2.1 Approximately confirm the length of the upright intersection pipe weld

In order to get the approximate length of the upright intersection pipe weld, first consider the approximate length of elliptical plane, and then use the short axis arc's length of the upright intersection pipe weld to replace the short axis length of oval perimeter, this modified formula for the calculation of results similar to the upright intersection pipe weld's length.

Following is the experienced formula of a flat oval perimeter's approximate calculation:

$$L = k\pi \left[3(a+b) - \sqrt{(a+3b)(3a+b)} \right] \quad (1)$$

Here: a - The short axis of a long oval. b - The long axis of a long oval.

K - Experience correction factor, the general desirability of 0.7 ~ 0.9, 0.9 desirable in this case. Circular arc's length is calculated as follows:

$$l = \alpha R / 180^\circ \quad (2)$$

$$\alpha = 2 \sin^{-1} (\phi_1 / \phi_2) \quad (3)$$

Here: α - the corresponding circular central angle for the intersection fraction of the short axis;

φ_1 - the branch pipe diameter; φ_2 - the main pipe diameter.

In order to obtain the lineal parameters of the intersection weld, put the long axis length of the ellipse in-plane in the formula (1) approximately equivalent to the largest long axis arc's length of the intersecting line in the formula (2), namely: $b \approx l$.

2.2 The subsection of the uprightness intersection of the sub-weld

According to JB/T4730-2005 《Nondestructive Testing of Pressure Equipments》 standard, then lookup table find the subsection's transparent frequency of five times, but in fact divided into 6, as shown in Figure 1. So divided in this way, the first transparent subsection and the paragraph 4 of the places of films, be to consistent exposure norms; Transmission 2 and 3, 5 and 6, they may be identical or close to the exposure norms.

3 Transmission thicknesses and the thickness of penetrating

3.1 Exploration of the transmission thickness

Test indicate that the X-ray test this case specimens, according to JB/T4730-2005 《Nondestructive Testing of Pressure Equipments》 standard as defined by the thickness of permeability (w), is to meet the standards for image quality requirements of the sensitivity of : $W = 2Tz$.

3.2 Determine the thickness of the penetration which affect the exposure parameters

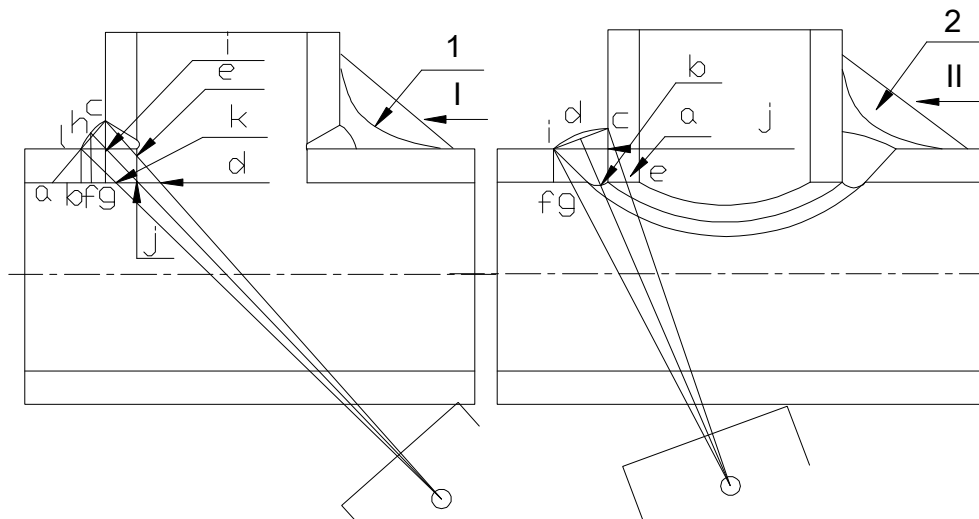


Figure 2 irradiate the type of rode、 type of inserted uprightness intersection pipe welds as the sketch

As shown on the left side in Figure 1, the first and fourth paragraph is a typical situation of ride at the uprightness intersection pipe welds. Actual transmission may be discrepancy, but with this kind of a typical situation roughly the same. To simplify the reasons to prevail, we use the typical situation. Assume that beam through the centre of the blocks along the base plate to high angular and circular to the centre position, as it is thorough-ray structure of such an ideal situation.

Estimate the h_j , ce and lk 's approximate thickness, we will be able to know the thickness of any difference between the two. Experience had been shown that, when the biggest difference is greater than 12mm thick above, will need to the black and white density of the weld to be effective detection control in the context of the standard requirements, there are certain difficulties. For testing, we need to use special measures. Otherwise, the sensitivity will drop, and the density difference will be expanded.

Comparison of the differences of thickness among to h_j , ce and lk :

$$\Delta \quad h_{\max} = h_j - lk = 18 - 8 = 10 \text{ mm} < 12 \text{ mm}$$

Know h_j , ce , lk 's the approximate thickness, we can be obtained in paragraph 1 and paragraph 4 of the average seam thickness:

$$W_{Q1} = \frac{h_j + ce + lk}{3} = \frac{18 + 16 + 8}{3} \approx 14 \text{ mm} \quad (4)$$

When select the exposure parameters, paragraph 1 and paragraph 4 of double-wall permeability as the average penetration thickness:

$$W_{qt} = 14 + 6 = 20 \text{ mm}$$

Plug-in the corner weld paragraphs 1 and 4 of the permeability right as shown in Figure 2, in order to give a estimation of its average thickness, we can set a better penetration and as a result of a higher frequency typical situation.

In order to obtain the better results of the penetration, beam's centre do and arc foot cable weld's centre c_i nearly vertical and equally, a in the between of b_e , ab in the ideal conditions may be 3 to 7 mm, now we suppose 5 mm; gf close the thickness of the block.

Now we take the thickness of ac, bd and gi for a comparison:

$$h_{\max} \text{ } bd - gi = 13 - 8 = 5 \text{ mm} < 12 \text{ mm}$$

The biggest difference of the thickness of transmission is less than 12 mm thickness, and do not need to take special measures can be irradiated as thoroughly.

The weld gap's thickness in the paragraph 1 and 4 to be seized with an average thickness as follows:

$$W_{c1} = \frac{ac + bd + gi}{3} = \frac{9 + 13 + 8}{3} \approx 10 \text{ mm}$$

Select the exposure parameters, as double-wall permeability thickness of the average penetration: $W_{ct} = 10 + 6 = 16 \text{ mm}$

4. Placing film

Filmed by T3, specifications for the 180×80 (mm) or 180×60 (mm). As figure 2 shows, experiments show that, when using 1-2 in placing film form, effective weld penetration as a result of regional deformation divergence has become blurred image quality not to meet the requirements of sensitivity. When using I - II in placing film form, the film should be an extension of the arc weld surface and the center section of roughly parallel, so that the seam permeability effect of deformation as regional divergence has been effectively controlled, image quality sensitivity has been significantly improved.

5. Transmission direction

When transmit of the fillet weld, in order to obtain the better results, the beam center and the strengthened outside arc weld's surface as thoroughly as possible vertical, but must be taken into account X-ray machine penetration.

Table 1 a group of exposure parameters of the intersection weld of plug-in the corner

tablet	Focal length (mm)	Pipe's electricity (mA)	Tube voltage (kV)	Exposure time (min)	Black Difference		Image quality index	
					request	fact	request	fact
C-1	400	5	200	2	2.0 ~ 4.0	2.0 ~ 3.5	13	13
C-2	400	5	180	2	2.0 ~ 4.0	2.3 ~ 3.0	13	13
C-3	400	5	180	2	2.0 ~ 4.0	2.2 ~ 2.9	13	13
C-4	400	5	200	2	2.0 ~ 4.0	2.1 ~ 2.3	13	13
C-5	400	5	180	2	2.0 ~ 4.0	2.0 ~ 3.4	13	13
C-6	400	5	180	2	2.0 ~ 4.0	2.3 ~ 2.8	13	13
Remarks	Developing time is 3 ~ 5 min, developing temperature is 20 to 22 °C							

Table 2 a group of exposure parameters of seat ride to the intersection angle of the weld

tablet	Focal length (mm)	Pipe's Electricity (mA)	Tube voltage (kV)	Exposure time (min)	Black Difference		Image quality index	
					request	fact	request	fact
Q-1	450	5	220	2	2.0 ~ 4.0	2.2 ~ 3.6	13	13
Q-2	400	5	180	2	2.0 ~ 4.0	2.0 ~ 3.3	13	13
Q-3	400	5	180	2	2.0 ~ 4.0	2.3 ~ 3.4	13	13
Q-4	450	5	220	2	2.0 ~ 4.0	2.3 ~ 3.3	13	13
Q-5	400	5	180	2	2.0 ~ 4.0	2.3 ~ 3.1	13	13
Q-6	400	5	180	2	2.0 ~ 4.0	2.4 ~ 3.1	13	13
Remarks	Developing time is 3 ~ 5 min, developing temperature is 20 to 22 °C							

6. Transmission Results

The density difference and sensitivity of the actual transmission image can meet the

requirements of relevant standards (film imaging abbreviated).

7. Conclusion

7.1 Dividing the places of the films placed for the upright intersection pipe welds of three links

Estimate of the girth on the upright intersection pipe welds penetrated of three links - for more than $\phi 108$ mm outer diameter of the upright intersection pipe welds of three links, the experience formula (1) can be used for approximate estimation. Dividing the places of the films placed by the estimation value will not have a significant accumulation of errors. Dividing the places of the films placed shall be an even number on condition to meet the stipulation of the standards. Subparagraph shall be compartmentalized firstly at the upper levels of the axis position as the center of two fragments, and then compartmentalize the others.

7.2 Estimation of the weld thickness differences penetrated to be the vertical angle to three intersecting and the thickness of the average penetration.

Image quality sensitivity can be determined on standard-setting, the general meets the requirements. Riding a block and insert three links to the vertical angle of intersection penetration weld thickness of a typical model can be determined under the conditions of effective weld penetration thick as the biggest regional difference, if the thickness deviation less than or equal to 12 mm, the black difference and sensitivity can be controlled within the limit of the standard permit. Using the above method to estimate the thickness of the average penetration helps determine a more appropriate exposure parameters.

7.3 Dispose film

To avoid the deformation of the upright intersection weld penetrated as the divergence enlarge it should be used in Figure 2 1-II, the extension surface of the film should be parallel with the center section of the arc weld roughly; Figure 2 should not be used 1-2 means.

7.4 Transmission direction

When three links to the upright intersection weld penetrated, and its radiation beam direction should be broadly satisfied approximate vertical with the section of the centre arc weld surface, it is necessary to consider the X-ray machine's full penetration capability.

7.5 Exposure parameters

Generally speaking, the upright intersection weld width (branch pipe direction) is the smaller one; the exposure voltage on the level axis section at the top of the upright intersection weld with the differences of others' will be smaller. The longitudinal seam width (Extension of direction) is bigger; the exposure voltage on the level section at the top of the upright intersection weld with the differences of others' voltage will be greater.

The upright intersection plug-in pipe to three intersecting as weld penetrated, the exposure voltage on the level axis section at the top of the upright intersection weld with the differences of others' are generally 15 to 30 kV.

The upright intersection ride-in pipe to three intersecting as weld penetrated, the exposure voltage on the level axis section at the top of the upright intersection weld with the differences of others' are generally 20 to 50 kV.

7.6 Image Quality

In this case's typical conditions, the black differences of the film effective assessment region can be controlled within a 2.0 to 4.0 limit by JB/T4730-2005 《Nondestructive Testing of Pressure

Equipments》 standard. The image quality in film effectively assessing region can meet the requirements of the sensitivity in the image quality by JB/T4730-2005 《Nondestructive Testing of Pressure Equipments》 standard.

References:

JB/T4730-2005 《Nondestructive Testing of Pressure Equipments》

National Development and Reform Commission issued

China special equipment NDT personnel training materials 《Ray detection》

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