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Test Procedure

REQUIREMENTS FOR THE COLD BORE TUBE TO COLLAR FLANGE ("COLLERETTE") FILLET WELD OF THE LHC DIPOLE AND QUADRUPOLE COLD MASSES FOR MANUFACTURERS

CATALOGUE OF TYPICAL DEFECTS AND CORRECTIVE ACTIONS

Abstract

This procedure is intended to provide a guideline for identifying possible defects in the cold bore tube to collar flange fillet weld and to indicate procedures defining how to deal with such NCRs.

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History of Changes

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Original	April 29, 2005	-	-
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1. INTRODUCTION

In the first quarter of the year 2005, a campaign of visual inspection of the external envelope of the main dipole cold masses was organized at CERN with a special attention paid to the fillet weld that joins the collar flange ("collerette") to the cold bore tube extremity following a specification sheet defined by the CERN metallurgy section [1]. In total, 113 cold masses have been inspected, i.e. 452 c.b.t. to collerette welds. Thanks to this campaign, a comprehensive list of the recurrent defects could be established according to the international standard ISO 6520-1, 1998 [2]. The quantity of defects observed is summarized hereafter in Table 1.

	DEFECTS	TOTAL OF 452 WELDINGS (113 CMs inspected)	
		N	%
Root	Root concavity	6	1%
	Corrosion	14	3%
	Root porosity	0	0%
	Total penetration	40	9%
	Scaled surface	24	5%
	Temper colour	96	21%
Crown	Corrosion	22	5%
	Scaled surface	0	0%
	Temper colour	23	5%
	Brushing not performed	2	0%

Table 1: Defects observed during the visual inspection

Because a significant number of defects were observed during the above mentioned campaign, the AT-MAS Group has decided to implement a reinforced inspection plan at the CMAs' premises, at the cold mass reception at CERN and at the cryo-dipole arrival in building SMI2.

This document reminds the requirements imposed to the c.b.t. to collerette weld in terms of area cross-section and penetration.

Then, it compiles a description and photographs showing the different types of defects in view of improving the quality control and of making it more uniform amongst the different production sites and reception teams.

The inspection shall be mainly visual and it shall be completed by a radiographic examination according to the scheme defined in Section 3 hereafter.

2. REQUIREMENTS FOR THE C.B.T. TO COLLERETTE WELD

When using adequate welding parameters and backing gas (pure Argon) for the tack welding and welding operation to join the collerette to the cold bore tube as per Figure 1 below, the inner wall of the c.b.t. is normally free of coloured areas.

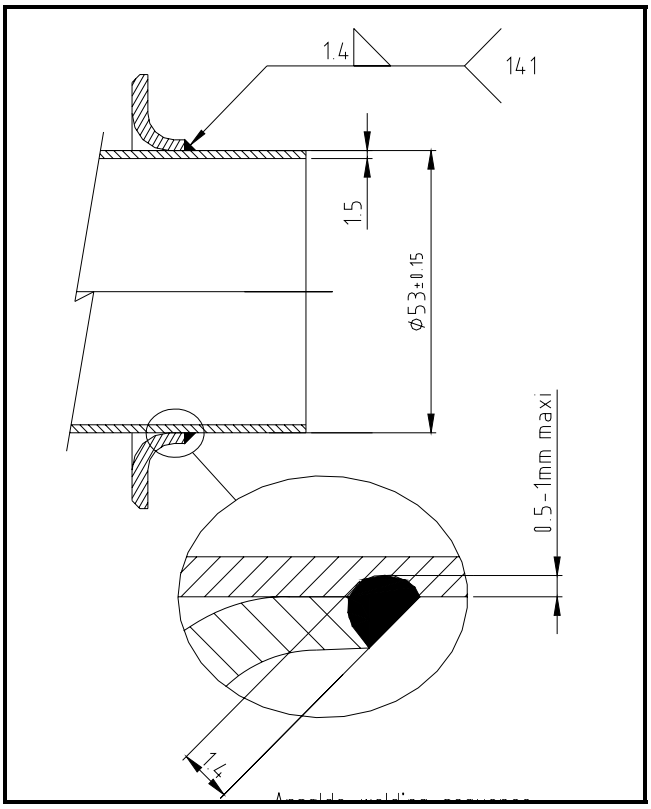


Figure 1: Dimensional requirements for the fillet weld

The required area cross-section of the weld and the allowed penetration are reminded in Figure 1.

Figures 2 & 3 below show a satisfactory weld, without brushing.

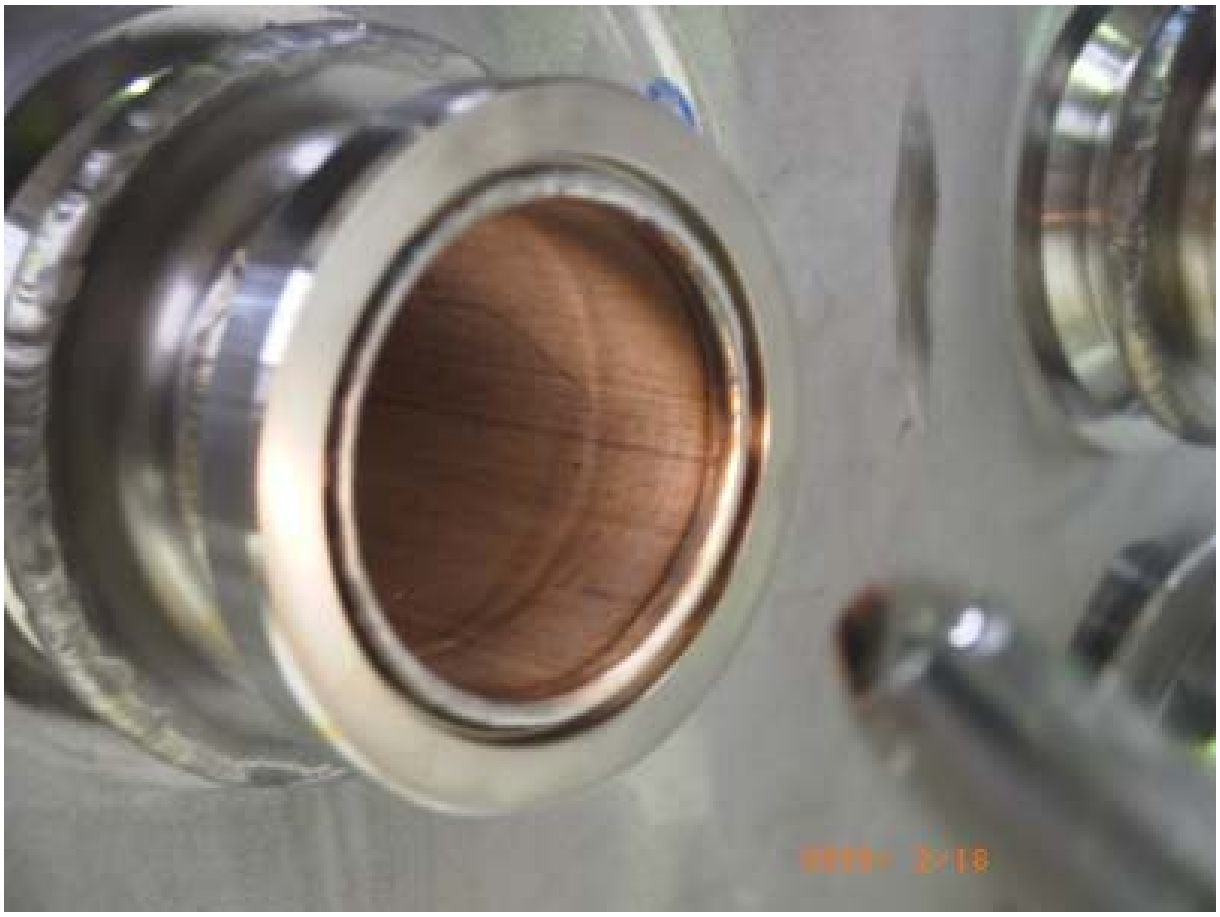


Figure 2: C.b.t. to collerette weld, free of defect

Figure 3: C.b.t. to collerette weld, free of defect

ACTION PLAN

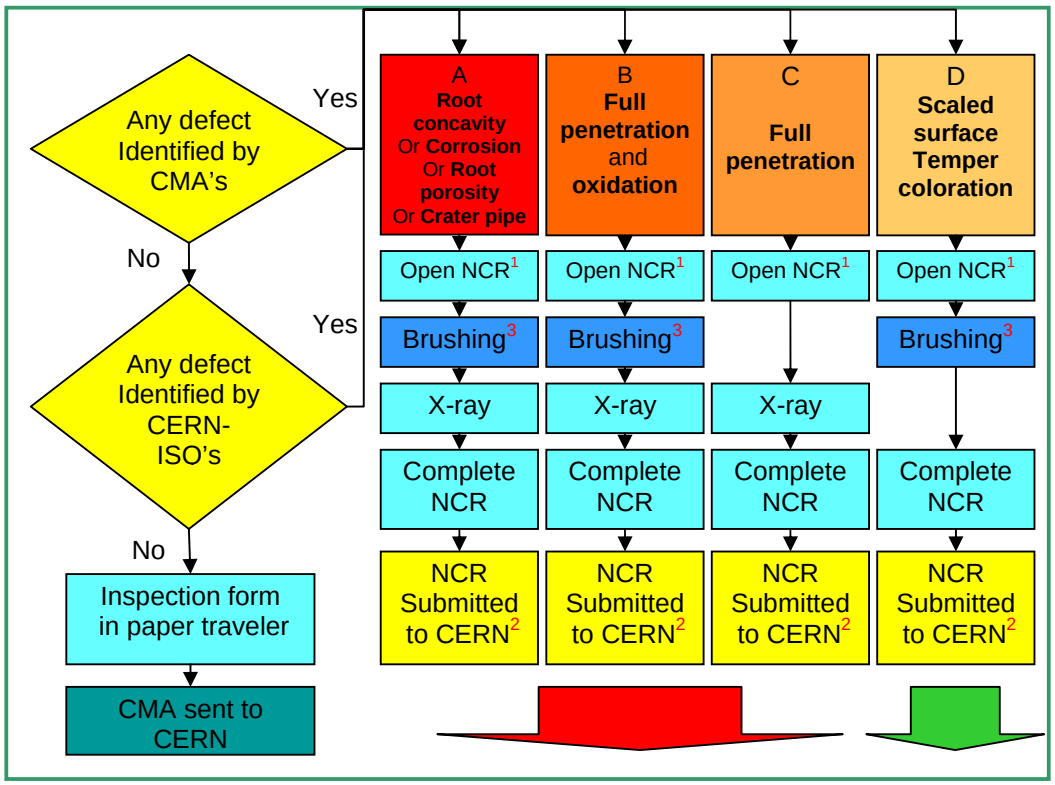
The defects observed during the above mentioned campaign have been classified in 4 groups called A, B, C and D as shown hereafter.

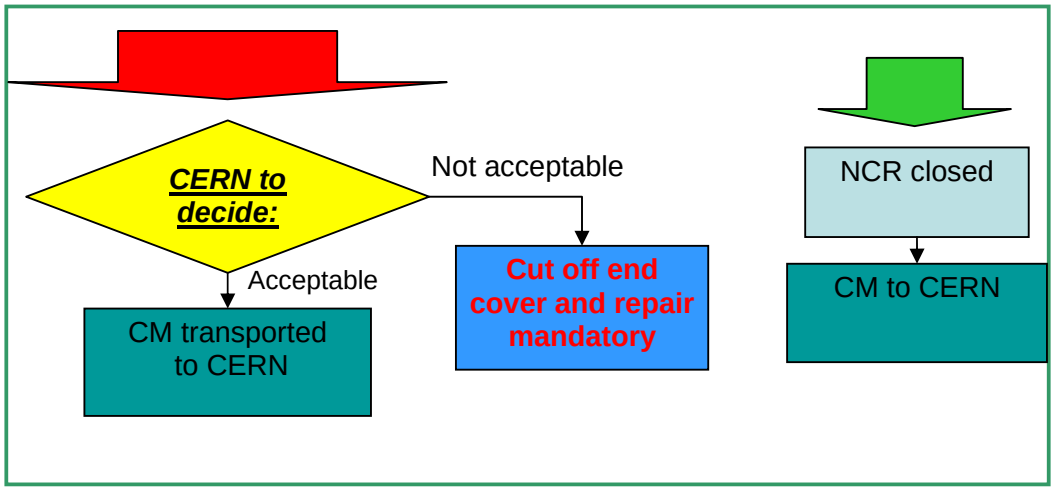
All the dipole and quadrupole cold masses, including those already stored or cryostated and stored on CERN site shall be checked for the 4 groups of defects according to the following scheme.

Category A represents the more severe defects.

Categories have decreasing relevance value from A to D.

Important: See explicative notes next page.





1) Open NCR: In order to clearly identify the defect, a picture(s) has to be added to the Non Conformity Report. Olivier.Crettiez@cern.ch and Simon.Cuzin@cern.ch shall be added to the distribution list of this document
2) NCR submitted to CERN: Olivier.Crettiez@cern.ch and Simon.Cuzin@cern.ch shall be added to the distribution list of this document
3) Brushing: It is forbidden to brush the inner wall of the tube on his entire periphery if not necessary. The brushing zone must be restrained and must only concern the affected zone. The brushing must be done using a stainless steel brush exclusively dedicated to this task. The use of corindon flap wheel inside the cold bore tube is forbidden and more generally, the brushing with such corindon wheel is not permitted on the CMs. Such tooling must be removed from the production.

A short description and examples of defects are shown in the following sections.

3. GROUP A

3.1 ROOT CONCAVITY – RETASSURE A LA RACINE - WURZELRÜCKFALL

A root concavity is a shallow groove due to the shrinkage of a (butt) weld at the root side.

Manque d'épaisseur à la racine d'une soudure bout à bout au retrait dû metal fondu.

Vertiefung in der Wurzellage infolge Schwindung bei einer Stumpfnaht.

This imperfection is referred to as defect N°515 according to the international standard ISO 6520-1, 1998.

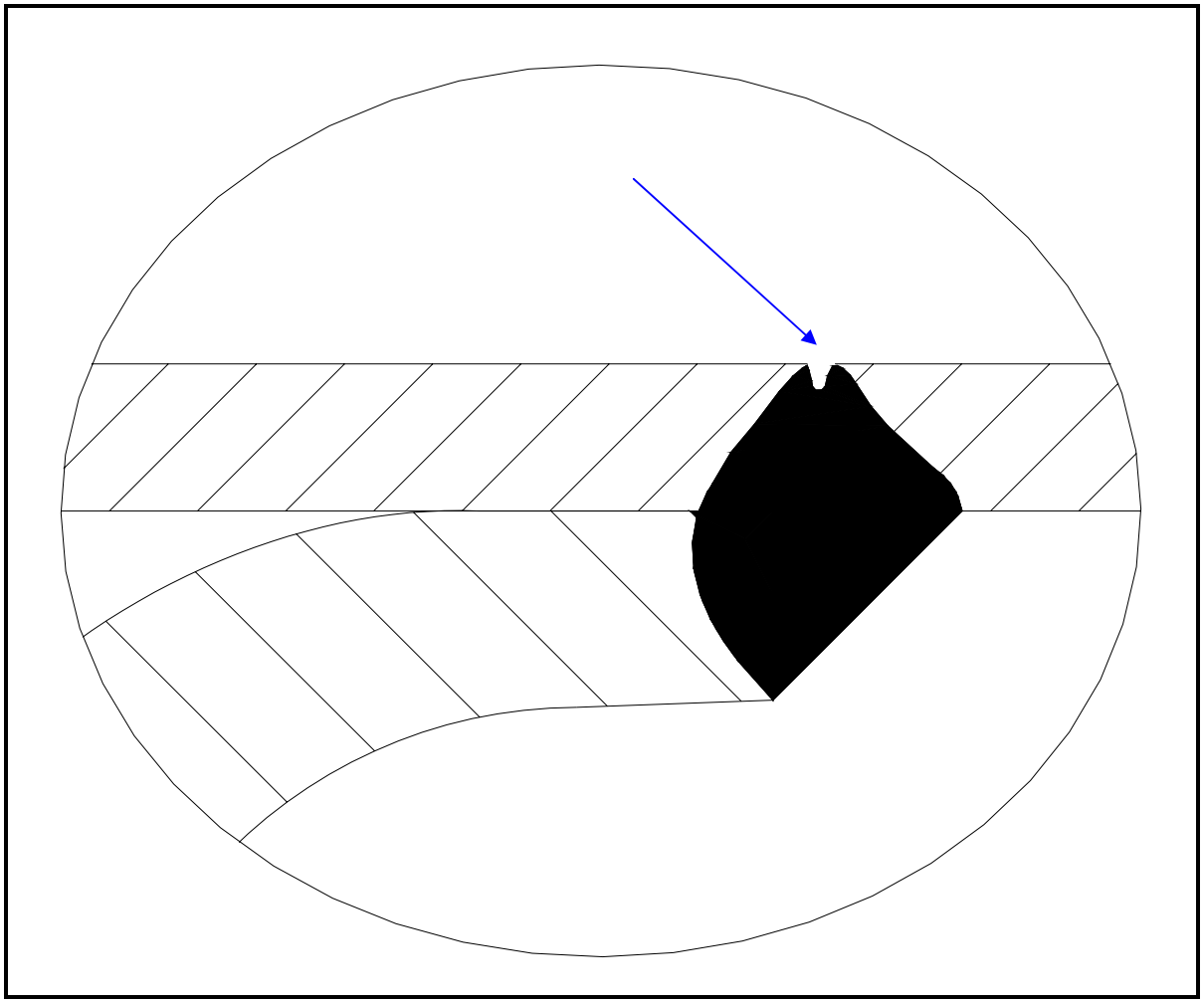


Figure 4: Root concavity – Defect N°515

Figure 5: Root concavity – Defect N°515

Figure 6: Root concavity – Defect N°515

Figure 7: Root concavity – Defect N°515

3.2 CORROSION – CORROSION - KORROSION

More or less fast degradation of the initial metal state of a material, eventually until its destruction, under the action of the ambient conditions and by a process other than mechanical, generally chemical or electrolytic.

Dégradation plus ou moins rapide de l'état métallique initial d'un matériau, pouvant aller jusqu'à sa destruction, sous l'action du milieu ambiant et par un processus autre que mécanique, généralement chimique ou électrolytique.

Mehr oder weniger schnelle Abnahme des metallischen Anfangszustands, eventuell bis zur vollständigen Zerstörung des Materials. Erfolgt durch nicht-mechanische, chemische oder elektrolytische Prozesse.

Figure 8: Corrosion

Figure 9: Corrosion

Figure 10: Corrosion

Figure 11: Corrosion

3.3 ROOT POROSITY- ROCHAGE –POROSITÄT IM WURZELBEREICH

Root porosity is a spongy formation at the root of a weld due to bubbling of the weld metal at the moment of the solidification.

Un rochage est une formation spongieuse à la racine d'une soudure due à un bouillonnement du métal fondu au moment de sa solidification.

Schwammige Ausbildung der Nahtwurzel als Folge von Blasenbildungen des Schweissgutes bei der Erstarrung.

This imperfection is referred to as defect N°516 according to the international standard ISO 6520-1, 1998.

Figure 12: Root porosity – Defect N°516

Figure 13: Root porosity – Defect N°516

3.4 CRATER PIPE – RETASSURE DE CRATERE - ENDKRATERLUNKER

Crater pipe is a shrinkage cavity at the end of a weld run that is not eliminated before or during subsequent weld runs.

De façon générale une retassure est une cavité due au retrait du métal pendant la solidification. En particulier une retassure de cratère est une retassure en fin de passe, non éliminée avant ou pendant l'exécution des passes suivantes.

Lunker am Ende einer Schweissraupe, der weder vor noch durch nachfolgende Schweissraupen beseitigt wurde.

This imperfection is referred to as defect N°2024 according to the international standard ISO 6520-1, 1998.

Crater pipe is also an open crater reducing the cross-section of the weld, in this case it is called end crater pipe.

Une retassure peut également être ouverte réduisant la section transversale de la soudure, elle est appelée dans ce cas retassure ouverte de cratère.

Offener Endkrater, der die Querschnittsfläche der Schweissnaht vermindert.

This imperfection is referred to as defect N°2025 according to the international standard ISO 6520-1, 1998.

The pictures 14 and 15 showing such defects were not taken from magnet cold masses as, so far, this kind of defects has never been observed [3].

Figure 14: End crater pipe – Defect N°2025

Figure 15: End crater pipe – Defect N°2025

4. GROUP B

4.1 FULL PENETRATION AND OXIDATION – PLEINE PENETRATION ET OXIDATION – VOLLE PENETRATION UND OXIDATION

The requirement for a fillet weld is normally defined by his area cross section. In order to satisfy the specific need of the LHC machine, a penetration depth inside the cold bore tube was added representing a maximum of 2/3 of the section tube (Figure 1).

In consequence, this imperfection in our case is not refered in the international standard. Nevertheless, it could be compared to a melt through, defect N°5043 according to the international standard ISO 6520-1, 1998.

Une soudure d'angle est normalement définie par sa section transversale. Dans le but de satisfaire les besoins spécifiques du LHC, une valeur de pénétration à l'intérieur du tube cold bore a été ajoutée représentant un maximum de 2/3 de la paroi du tube (Figure 1).

C'est pourquoi, cette imperfection dans notre cas n'est pas référencée dans la norme. Cependant, elle peut être comparée à une pleine pénétration, défaut N°5043 selon la norme internationale ISO 6520-1, 1998.

Eine Winkelschweissung ist normalerweise definiert durch die Form des Querschnitts. Um der besonderen Anforderung der LHC Maschine zu genügen, wurde die Eindringtiefe im Strahlrohr (cold bore) zusätzlich spezifiziert. Diese sollte 2/3 der Rohrwandstärke betragen (Abb. 1).

Diese Unregelmssigkeit ist nicht berücksichtigt in der internationalen Normierung. Trotzdem kann die vollständige Durchschmelzung (Penetration), als Derfekt No. 5043 entsprechend der internationalen Norm ISO 6520-1, 1998 zum Vergleich herangezogen werden.

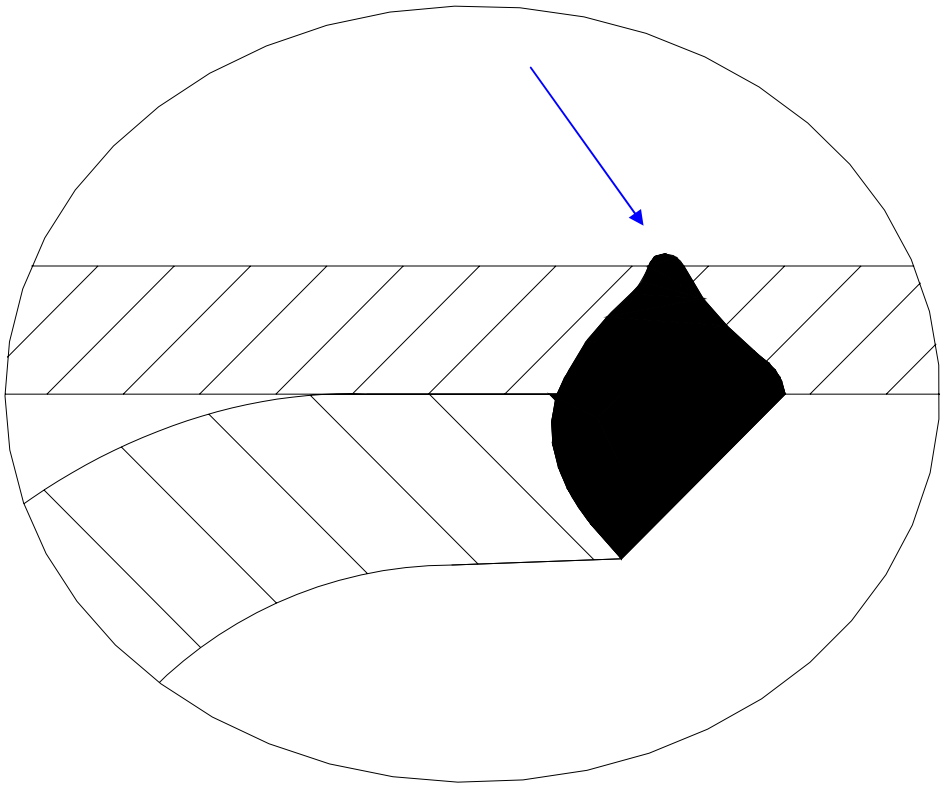


Figure 16: Full penetration and oxidation

Figure 17: Full penetration and oxidation

Figure 18: Full penetration and oxidation

5. GROUP C

5.1 FULL PENETRATION– PLEINE PENETRATION– VOLLE PENETRATION

Please refer to the 5.1 paragraph.

Figure 19: Full penetration

6. GROUP D

6.1 SCALED SURFACE – SURFACE CALAMINEE – VERZUNDERTE OBERFLÄCHE

Scaled surface is an heavily oxidized surface in the weld zone.

Une surface calaminée est une forte oxidation de la surface en zone fondue.

Stark oxidierte Oberfläche im Schweissbereich.

This imperfection is referred to as defect N°613 according to the international standard ISO 6520-1, 1998.

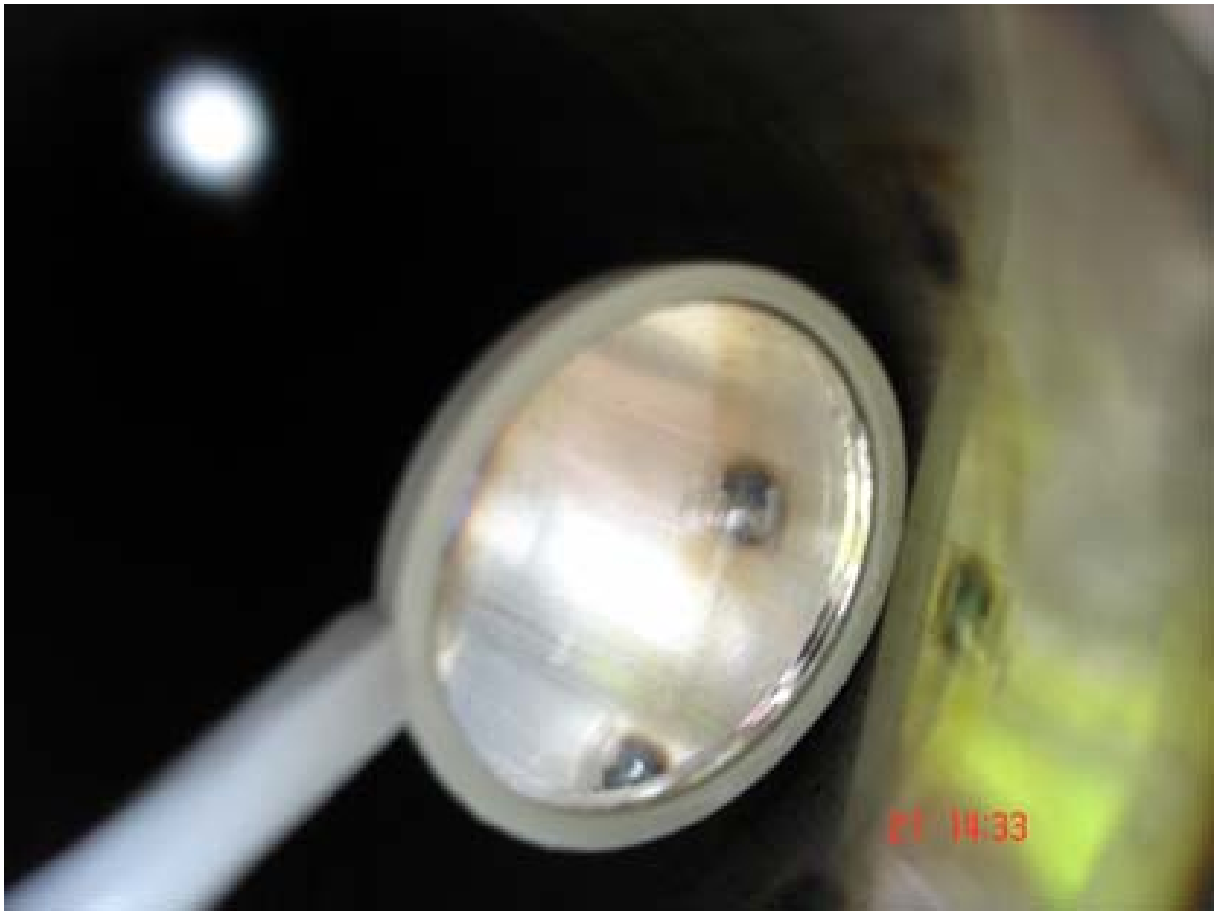


Figure 20: Scaled surface – Defect N°613

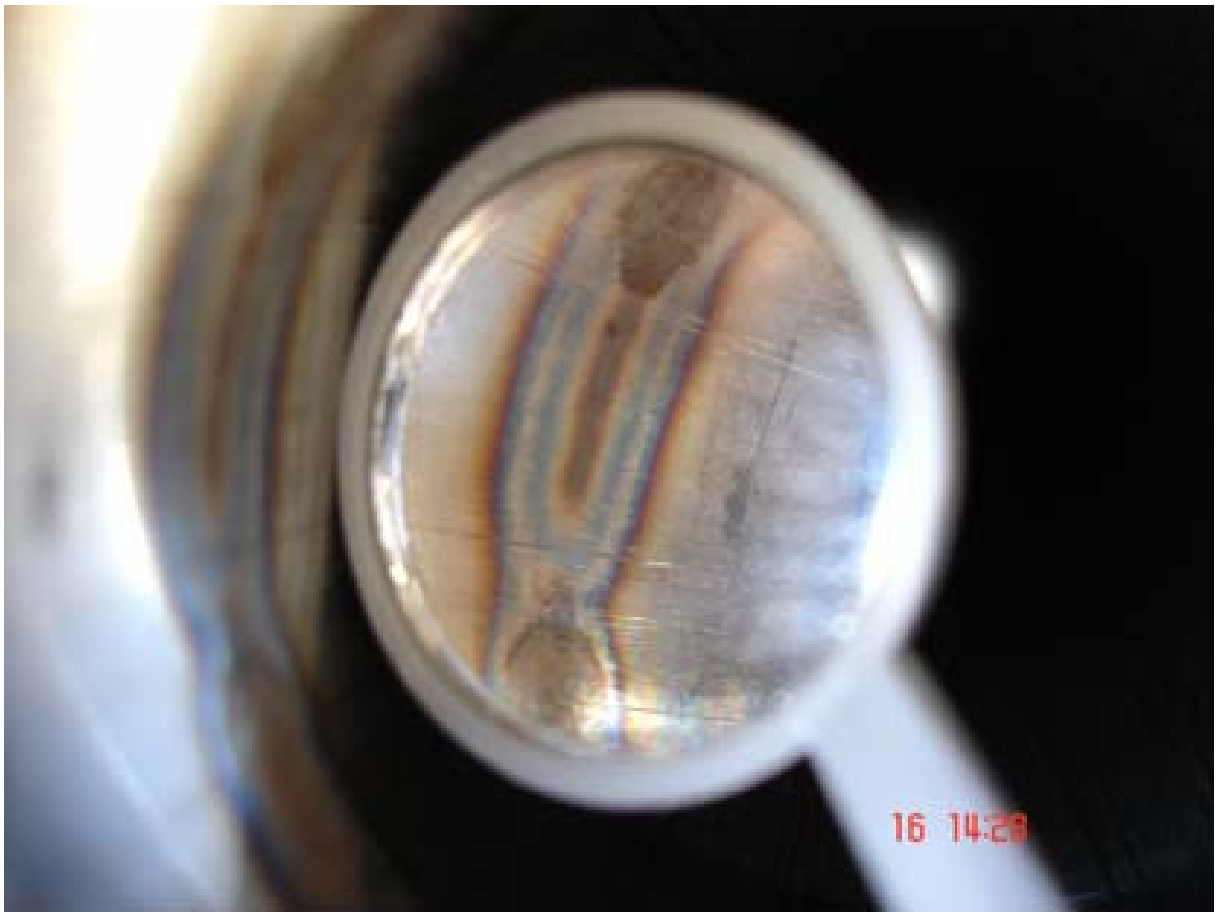


Figure 21: Scaled surface – Defect N°613

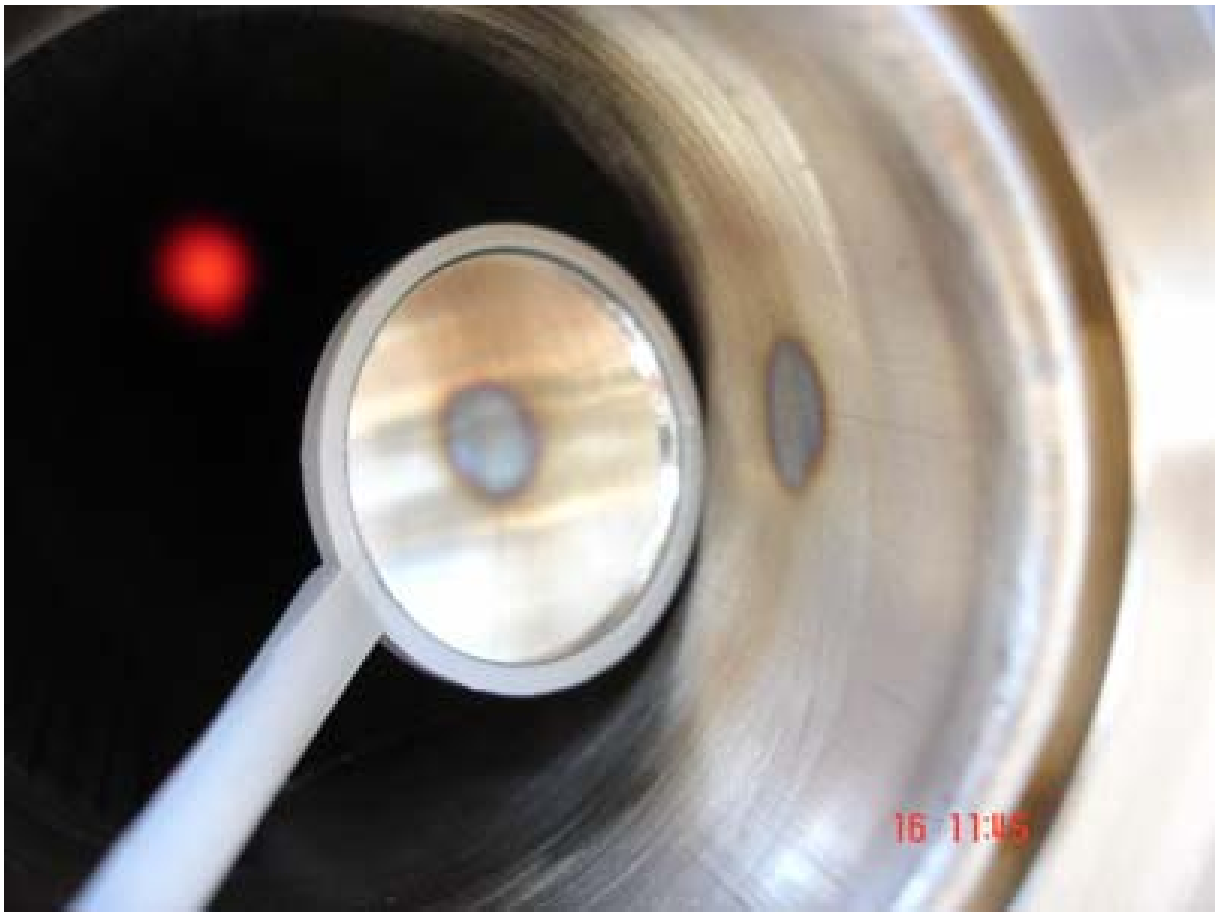


Figure 22: Scaled surface – Defect N°613

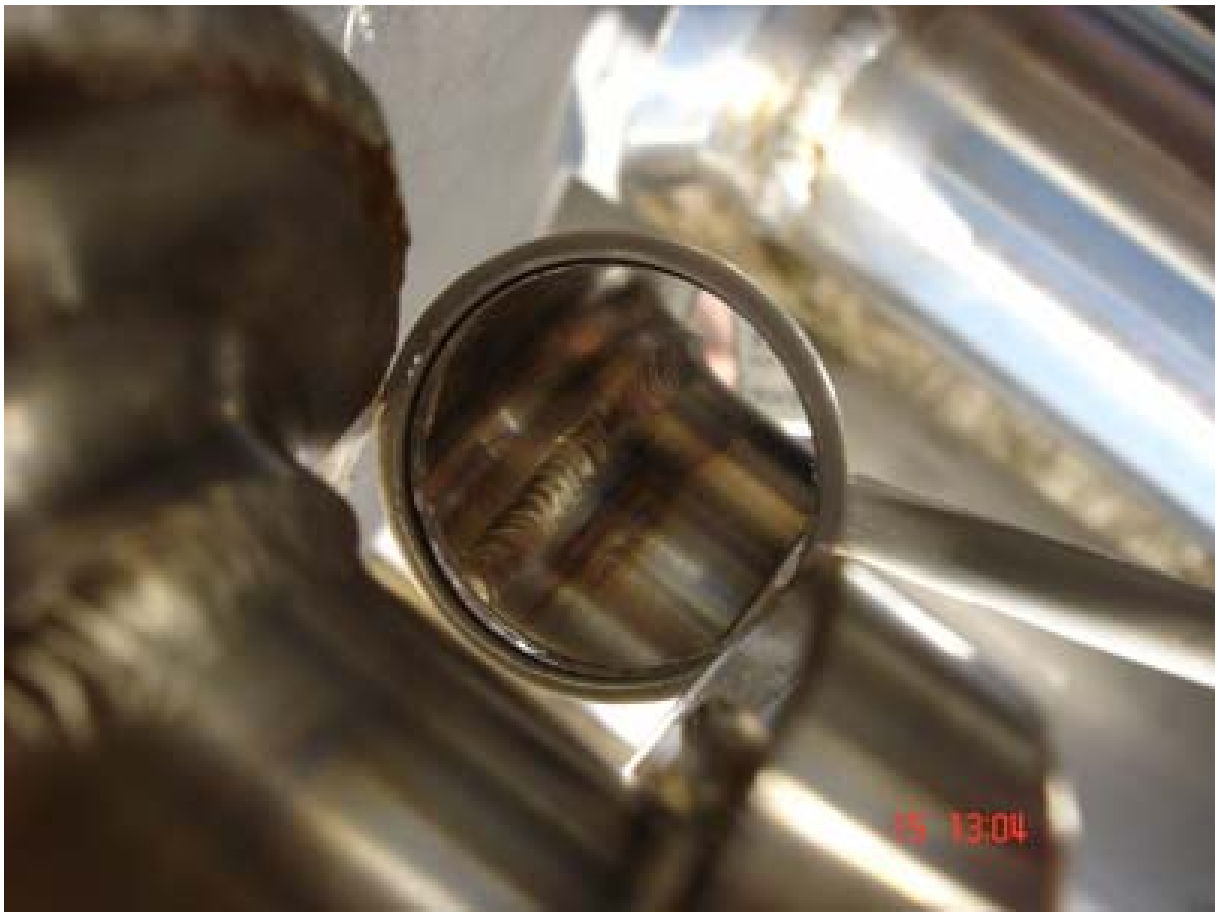


Figure 23: Scaled surface – Defect N°613

6.2 TEMPER COLOR – COULEURS DE REVENU - ANLAUFFARBEN

A temper color is a lightly oxidized surface in the weld zone, e.g. in stainless steel.

Une couleur de revenue est une légère oxidation de la surface en zone fondue, par exemple dans les aciers inoxydables.

Leicht oxidierte Oberflache im Schweissbereich, z.B. bei nichtrostendem Stahl.

This imperfection is referred to as defect N°610 according to the international standard ISO 6520-1, 1998.

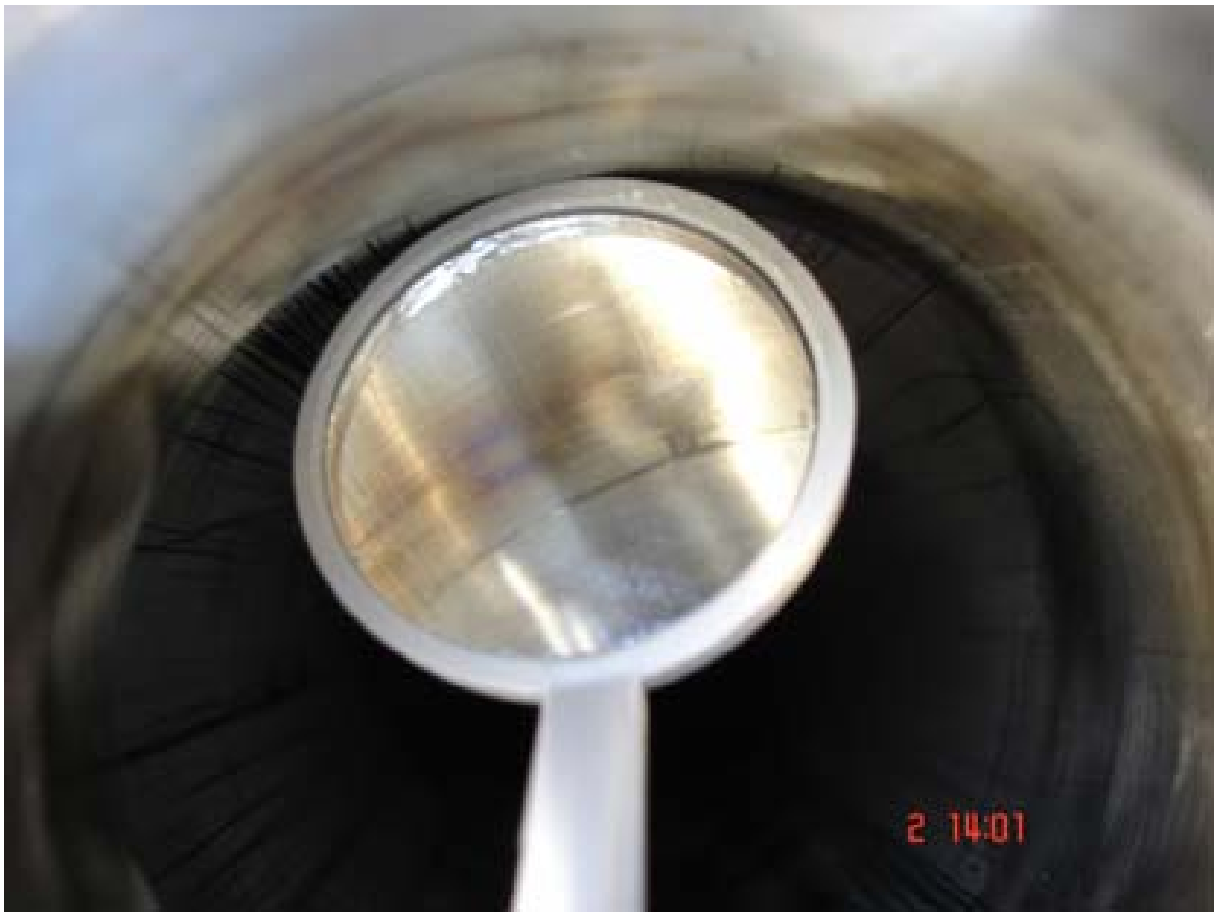


Figure 24: Temper color – Defect N°610

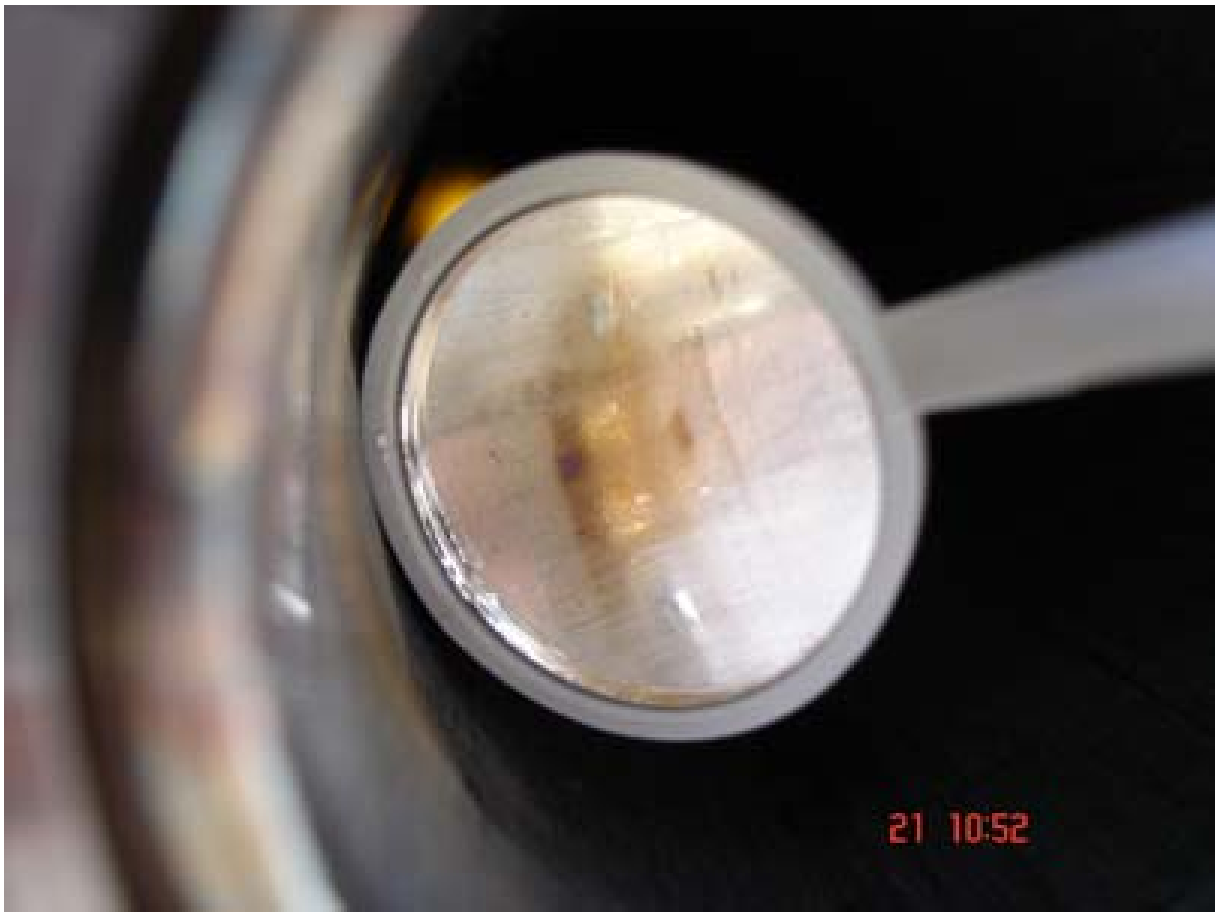


Figure 25: Temper color – Defect N°610

7. REFERENCES

[1] TS/MME, “Soudure collerette – tube de faisceau dans les masses froides des aimants dipolaires LHC”, Specification de controle n° 05_01 rév. 0, CERN, Geneva, Switzerland, 2005

[2] International standard ISO 6520-1, “Welding and allied processes – Classification of geometric imperfections in metallic materials”, 1998

[3] TS/MME, “QRL investigation of quality of tack welds in tube F”, EDMS n°485362, S. Atieh, July 2004