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Choice of Probe-Couplant combination in Phased Array UT

ECNDT 2018

Goteborg, June 2018

Agenda

1. Choice of Probe-Couplant combination in PA UT
2. The International Standards on UT Couplants
3. The Tests Done
4. EHS Considerations
5. Conclusions

Choice of Probe-Couplant combination in PA UT

Scope of this paper

- *Phased array instruments can be used on a variety of surfaces: from flat and smooth pieces, to vertical surfaces, to rough welds or irregular curved surfaces*
- ***Our Target:** to investigate the best combination of probes, couplant gels and phased array instrument settings in order to obtain the most reliable and productive ultrasonic testing*

Parameters investigated:

- ✓ *Lowest gain to obtain 100% FSH*
- ✓ *Time of effective coupling*
- ✓ *Performance on non-flat / vertical*
- ✓ *Resolution of the indications*

Coupling agents tested:

- ❑ *Water*
- ❑ *Water with additives (Elite W4US)*
- ❑ *Glue*
- ❑ *Elite UT Couplants: Fyp, Matrix, C333*

The International Standards on UT Couplants

ASME Sez. V, Art.4: T433, T477, T462, T492
ASME Sez. V, Art.5: T533, T577, T562, T592

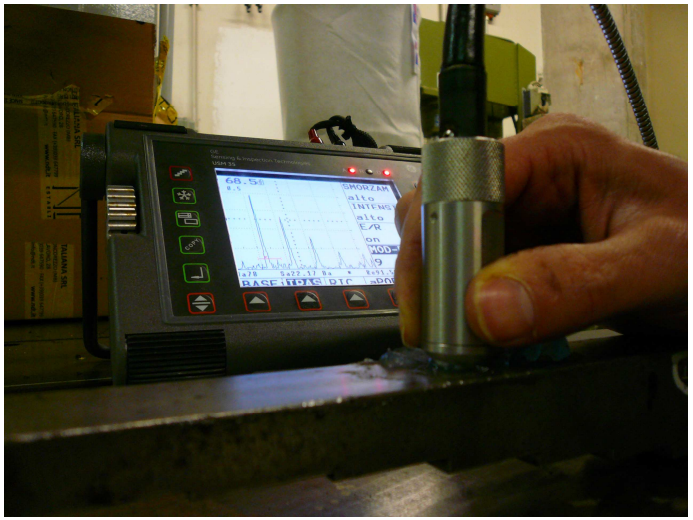
- **ASME Sez.V T433 e T533:** "*Couplants used on nickel base alloys shall not contain more than 250 ppm of sulphur*" "*Couplants used on austenitic stainless steel or titanium shall not contain more than 250 ppm of halides (clorides plus fluorides)*"

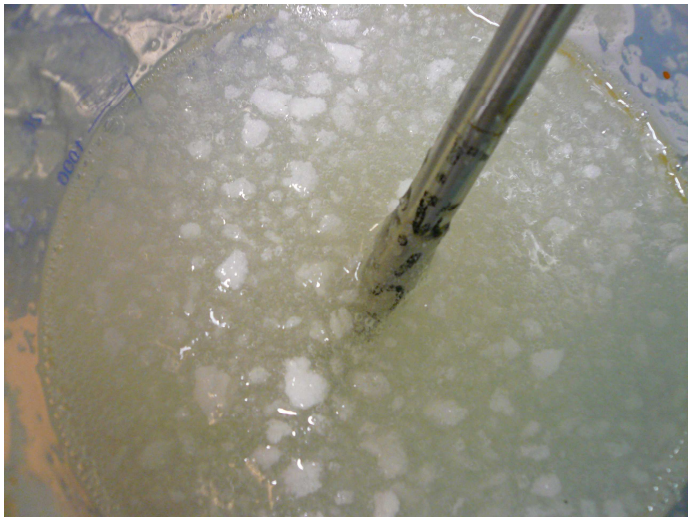
- **ASME Sez.V T477 e T577:** "*post-examination cleaning should be conducted as soon as pratical and using a process that does not adversely affect the part*"

UT Couplants specific line **(e.g. Elite couplants)**	**Un-specific UT Coupling agent** **(e.g. glue, grease, oils)**
✓ Certificate < 250ppm sulphur and halides	✖ Can contain high sulphur and halides
✓ Fast and safe post-examination cleaning of the piece	✖ Long/difficult post-examination cleaning
✓ Safety Data Sheets of the couplants	✖ Can damage the pieces or the probe
	✖ No safety data sheet available

The International Standards on UT Couplants

ASME Sez. V, Art.4: T433, T477, T462, T492
ASME Sez. V, Art.5: T533, T577, T562, T592





<u>Specific</u> UT Couplant

(e.g. Elite Fyp, Matrix, C333, W4US…)

✓ Fast to apply and remove

✓ Protection of piece and probe

✓ Higher quality of the signal trasmitted by the probe

<u>Un-</u>Specific UT Couplant

(e.g. glue, grease, oils)

✖ Difficult to apply and remove

✖ Piece and probe not protected

✖ Lower quality of the signal forces the operator to increase the gain resulting in higher background noise

The tests done

Different coupling agents and their effect on inspection

- *Water is a frequently used coupling agent, but:*

- ✖ Drops easily if the surface is not flat
- ✖ Can cause corrosion
- ✖ Has low superficial tension
- ✖ Creates bacteria algae and fungi that stink and could be dangerous for the operator

- *Coupling additives may be added to the water to improve its properties…*

The tests done

Different coupling agents and their effect on inspection

- *Why using a water additive in your AUT inspections?*

- Water Additives can be used for immersion ultrasonic testing, with squirters but also for standard applications with manual or AUT

✓ Facilitate the adhesion of water on the surfaces, reducing drastically the microbubbles contained in it, for the maximum reliability of the control

✓ Protect the immersed pieces and the mechanical parts of the ultrasonic systems

✓ Prolong the life of the bath and guarantee the hygiene of the workplace (no bacteria, algae, fungi)

✓ Do not produce foam

✓ Can be used also on composite materials

The tests done

Different coupling agents and their effect on inspection

FLAT AND SMOOTH SURFACES

	h2o				glue				FYr				Matrix				C 333			
	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical
2,25 L	13,5	seconds	good	no	13,5	minutes	good	drops	13	hours	very good	stays on	**12**	weeks	very good	stays on	13,5	hours	very good	stays on
5 L	13,5	seconds	good	no	13,5	minutes	good	drops	13	hours	very good	stays on	**12**	weeks	very good	stays on	13,5	hours	very good	stays on
10 L	21	seconds	good	no	22	seconds	good	drops	21	hours	very good	stays on	**19,5**	weeks	very good	stays on	21	hours	very good	stays on

FLAT AND ROUGH

	h2o				glue				FYr				Matrix				C 333			
	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical
2,25 L	15	seconds	good	no	15	minutes	good	drops	15	hours	very good	stays on	**11,5**	weeks	very good	stays on	14	hours	very good	stays on
5 L	21,5	seconds	good	no	20	minutes	good	drops	19,5	hours	very good	stays on	**16,5**	weeks	very good	stays on	20,5	hours	very good	stays on
10 L	23	seconds	good	no	22,5	seconds	good	drops	21	hours	very good	stays on	**18,5**	weeks	very good	stays on	22	hours	very good	stays on

CURVED AND IRREGULAR

	h2o				glue				FYr				Matrix				C 333			
	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical	dB	Lasting	Resolution	Vertical
5 L	30	<1 second	ok	no	29	seconds	ok	no	28	hours	very good	stays on	**25**	hours	very good	stays on	28	hours	very good	stays on

Note: Gain in dB is always set on 100% FSH (full screen Hight) on known reflector

- Specific couplants for AUT and MUT always perform better than only water or glue/grease
- The difference in signal is very significant (up tp 5 dB all other factors being the same)
- The difference grows as the inspection becomes more “difficult”: curved, irregular, rough surfaces, not perfectly degreased (slightly oiled/dirty as it happens on the field)

The tests done

Different coupling agents and their effect on inspection

- Water injection coupling may give false indications located on inspection surfaces due to water flowing paths in front of the wedge. This effect can be eliminated by adding Elite W4US water additive for UT to the tap water, because it increases the superficial tension and reduces water droplets when working with phased array in automatic weld inspection

- Adding a water additive also eliminates the following problems:

✓ Water creates a “suction” effect every time I have to take the probe out from the surface to reposition it, which is very inconvenient for the operator because the probe is difficult to take out

✓ When moving the probe with only water as coupling agent, the probe is not moving smoothly: it tends to stuck making it difficult to move across the surface

✓ If the surface is not flat, water goes away too quickly to be used for manual inspection

✓ Wetting ability is always better with couplant additive compared to water only

The tests done

Performance of wetting agent on weld PA automated inspection of steel welds

- PA mechanized data acquisition is widely used on piping welds. Water irrigation is the most reliable, stable and inexpensive coupling medium. There are two major problems related to the use of tap water on carbon steel welds:

PA Automated Inspection with water only:

- Activation of rusting process (piece and/or machine parts)
- Generation of false calls generated by water flowing on the inspection surface

- Adding a water additive in PA automated inspection can help eliminate this problems

The tests done

Example of echoes generated by water

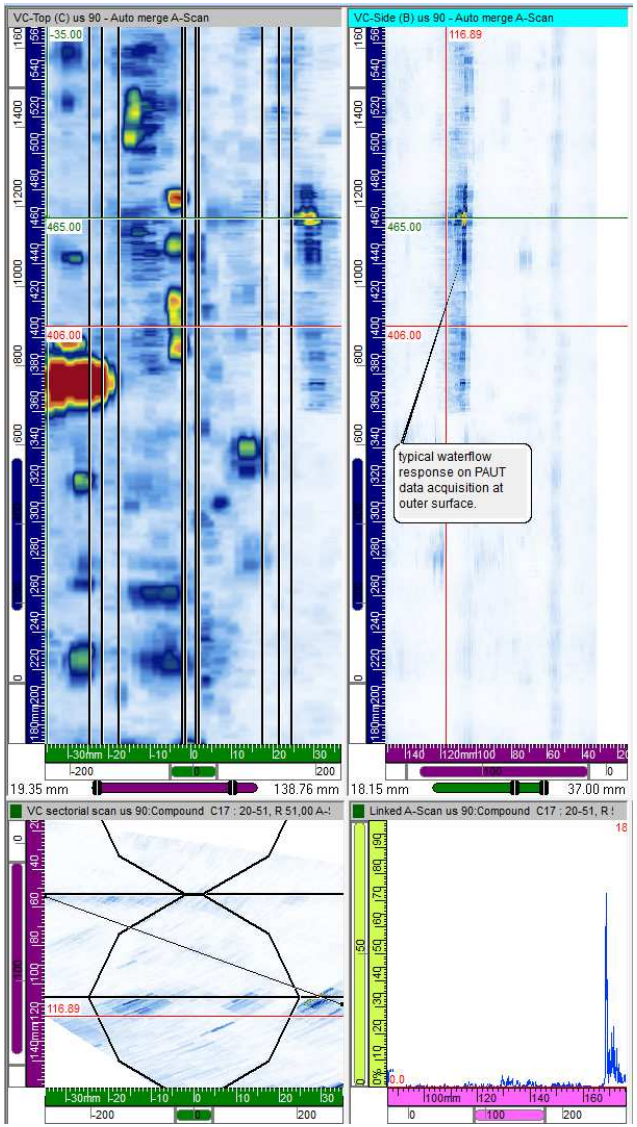


Figure 1: false calls due to water flow with Zetec UV3 arrangement

Figure 2: Typical IMG Anyweld scanner used for trials

The tests done

Example of echoes generated by water

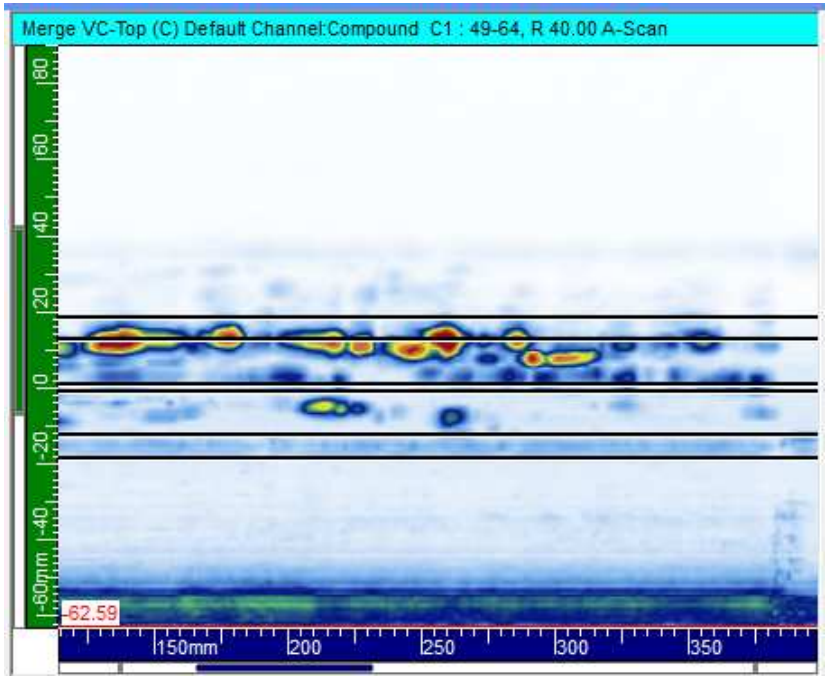
- The way to reduce the water false calls is to reduce water flow, but this may increase the risk of poor coupling

- The first trials has been conducted using a 64 element PA probe, 5 MHz, 0,75 mm pitch and a 60° SW wedge with a contact surface of 71x40 mm. (IMG AT25201 with wedge IA2-N60S-IHC); 2ml of tap water has been positioned on a standard plate surface and then encoded scan has been performed without any water addition using a Zetec Topaz 32 and a compound scan in order to monitor coupling on a large length of the wedge. The same test has been done with the same quantity of tap water with 5% addition of Elite W4US

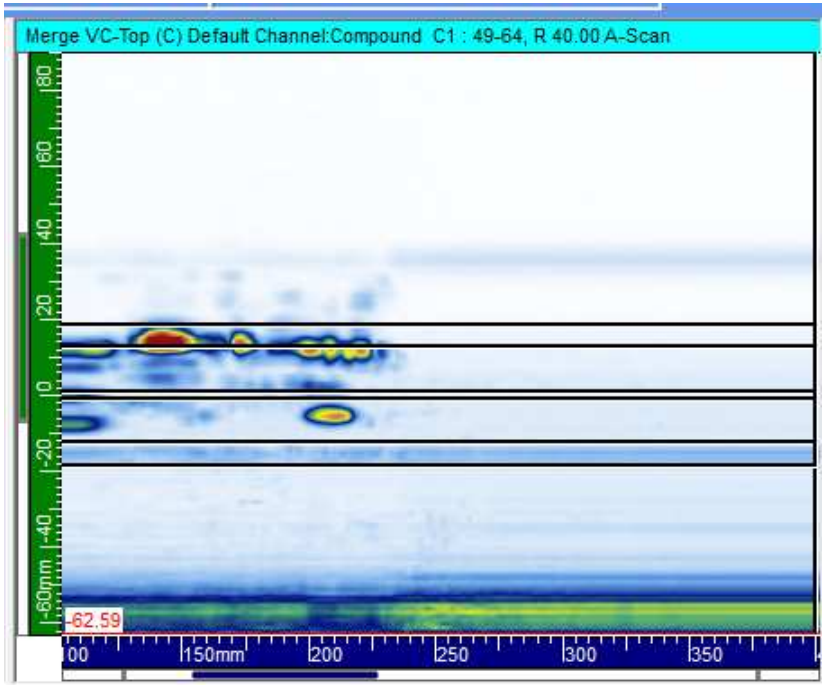
- The results shows that the coupling has been maintained for a scanning length at least double with the additioned water compared to tap water. (average value on 10 repeated scans)

The tests done

Example of echoes generated by water



Scan with 5% addition of Elite W4US



Scan with tap water only

The tests done

PAUT on composites materials

- Composite materials:
  - Flat surfaces (side of the stamping): very good wetting ability of Elite W4US compared to only water
  - Rough surfaces (other side): very good wetting ability of Elite W4US compared to only water

- In tanks with automated PAUT inspection:
  - Much longer life of the bath and better signal, even only at 5% dilution in water

The tests done

PAUT on steel plate welded

- Steel plate welded:
  - Rough weld surface: not big difference between water and water + Elite W4US additive on perfectly degreased surfaces
  - If the surface is even slightly oiled/greased as it can easily happen on the field, there is a big difference between water only and water + Elite W4US additive

The tests done

PAUT with Matrix couplant gel

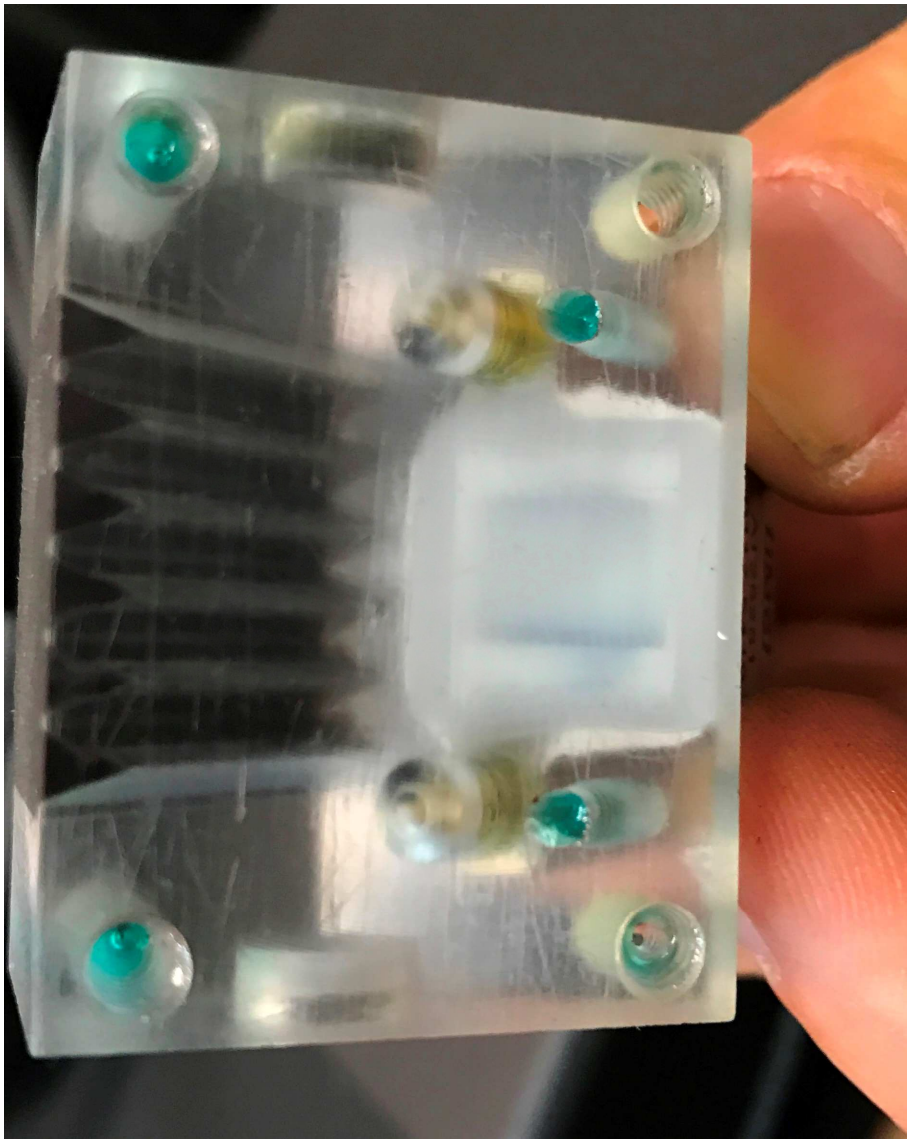
- Matrix UT couplant
  - Matrix couplants allows to gain as much as 5 dB compared to water or glue on circular surfaces (pipes) with flat wedges and irregular surface
  - Matrix performs a lot better on high frequencies (10 Mhz)
  - Matrix remains a soft gel usable for a very long time (weeks) without the need to re-apply

The tests done

Wedge – probe assembling

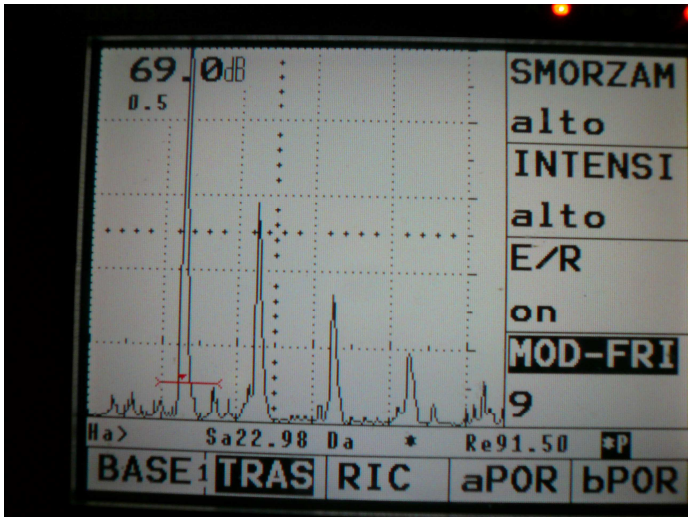
A correct and long lasting wedge – probe assembling is critical for an optimal PAUT inspection

- Using an un-specific grease or paste can lead to non-optimal assembling and short lasting performance
- Using Elite MHT couplant results in a very long time assembling with constant performance



High temperature applications

Real temperature ranges and operative performances



<u>Specific</u> UT High Temp Couplant

(e.g. Elite MHT, UHT, C200)

- ✓ Optimal signal intensity
- ✓ No harmful smoke
- ✓ Easy post examination cleaning of probe and piece
- ✓ Certificated from -50°C up to +600°C

<u>Un-</u>specific UT UT High Temp Couplant

(e.g. grease, oils)

- ✖ Significantly lower signal intensity
- ✖ High smoking potentially harmful
- ✖ «Frying» and dripping leaving residues on probe and piece very hard to clean
- ✖ No tested temperature range

Environmental, Health and Safety Considerations

Safety of the Couplants used

- A specific UT couplant has big safety advantages for the operator and the environment:

✓ Safe for the operator because:

- ✓ No hazard pictograms according to GHS / CLP
- ✓ Non toxic (like anti-icing fluids), not flammable (like oils), not smoky (like greases at high temperature), not irritant for the operator's hands

✓ Safe for the environment because:

- ✓ No hazard pictograms according to GHS / CLP
- ✓ Free of substances that make the waste toxic or harmful

✓ Safe for the pieces and the UT equipment:

- ✓ Not aggressive or corrosive for the piece/equipment and easy to remove

Environmental, Health and Safety Considerations

Test Certificates and Safety Data Sheets

NDT ITALIANA SRL	Revision nr. 2 Dated 16/6/2015
15.115 - W4US	Printed on 16/06/2015 Page n. 1/9

Safety data sheet

SECTION 1. Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Code: **15.115**
Product name **W4US**

1.2. Relevant identified uses of the substance or mixture and uses advised against

Intended use **U.S. Additive**

1.3. Details of the supplier of the safety data sheet

Name **NDT ITALIANA SRL**
Full address **Via del Lavoro 28**
District and Country **20863 Concorezzo (MB)**
Italy
Tel. +39 039647590
Fax +39 039647799
e-mail address of the competent person
responsible for the Safety Data Sheet **info@ndt.it**

NDT ITALIANA SRL
Via del Lavoro, 28
20049 – CONCOREZZO (MI)

UNI EN ISO 9001

SISTEMA DI GESTIONE PER LA QUALITA' *Quality System Management*	Pag 1 di 1 *Pag . of*
ATTESTATO DI CONFORMITA' ***Test Certificate***	**AC nr. 14** ***TC no.***

OGGETTO: ACCOPPIANTE PER ALTISSIME TEMPERATURE
Object: Couplant for very high temperatures

CODICE: 15.120 UHT *Code:*	S/N: *S/N:*	LOTTO: 120229U *Batch:*

We declare that the above mentioned couplant

Analyzed with ASME Sect. V Art. 6 App. II 641 e 642 procedure contains:

- Sulfur according to ASTM D 129	*< 50 ppm*
- Total halogen mentioned as chlorine according ASTM D 808	*< 50 ppm*

Conclusions

Advantages of a specific UT Couplant

<u>Specific</u> UT Couplant (e.g. Elite W4US, Matrix, Fyp, Fyr, C333, MHT, UHT, C200….)

- ✓ According to International Standards (e.g. ASME)
- ✓ Designed specifically for UT inspection
- ✓ Safety Data Sheets provided
- ✓ Protection of Probe and Piece
- ✓ Best signal quality
- ✓ Easy to apply and remove
- ✓ Lower total costs
- ✓ Easy to stock

<u>Un</u>-specific UT Couplant (e.g. glue, grease, oils)

- ✖ No certification provided
- ✖ Not specific for UT inspection
- ✖ No Safety Data Sheets
- ✖ No protection of probe and piece
- ✖ Significantly lower signal quality
- ✖ Hard to apply and remove
- ✖ Higher overall costs

Conclusions

Coupling agent used is critical in PAUT inspection

The use of a specific couplant on PAUT is even more critical compared to conventional UT, because:

✓ *Contact surfaces of PA's probes wedges are wider compared to conventional UT*

✓ *It's more critical to ensure a constant wetting ability*

✓ *PAUT inspections are mostly recorded and coupling consistency has to be guaranteed*

Conclusions

Why using a water additive in PAUT inspection

The use of a specific couplant on PAUT can:

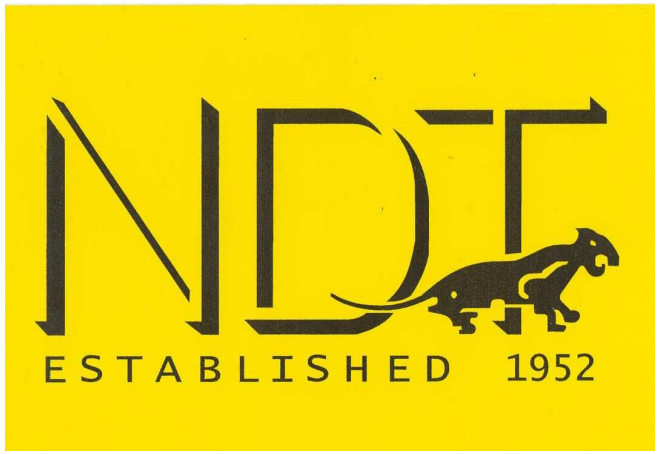
✓ Increase significantly the gain, especially in «difficult» conditions

✓ Reduce generation of false calls generated by water flowing on the inspection surface

✓ Protect the pieces and the mechanical parts of the ultrasonic systems

✓ Increase the time of effective coupling

✓ Prolong the life of the bath and guarantee the hygiene of the workplace (no odour, bacteria, algae, fungi)



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Michele Cevenini

NDT ITALIANA Proudly Supports Beat Leukemia ONLUS www.beat-leukemia.org
"The difference between difficult and impossible is that impossible takes longer. Miracles just require faith"

ECNDT 2018

Choice of Probe-Couplant combination in Phased Array UT

Phased array inspections are performed on a wide variety of surfaces, from flat to curved, from smooth to rough and irregular, from horizontal to vertical.

The purpose of this paper is to investigate the best combination of probes, couplant gels and phased array instrument settings in order to obtain the most reliable and productive ultrasonic testing even in difficult working conditions.

Different probes and couplants gels have been used throughout the tests carried out for this paper. Gain has been set on 100% FSH on known reflector, to compare different coupling agents and evaluate results about:

- *Gain: the lowest gain to obtain 100% FSH as indicator of performance and reliability of the phased array inspection;*
- *Time of effective coupling performance*
- *Resolution of the indications*
- *Possibility to work on non-flat/vertical surfaces*

Surfaces tested:

- *Flat and smooth surface (UT test blocks)*
- *Flat and rough surface (Weldings)*
- *Curved and irregular surface (Oil&Gas Pipes irregularly grinded)*

Manual and automatic applications have been investigated. Probes have been selected with different frequencies, wedge size and shape, to optimize inspection results. With the same purpose, different coupling agents have been tested: water, water with UT additives, glue, different UT couplant gels.

Results have been fit into a matrix to help PAUT operators have a reference guide of the best combinations of instrument settings, probes, couplant gels to obtain the most reliable and fast inspection in any type of situation in the NDT inspection field.

Results show that the use of a specific couplant on PAUT is even more critical compared to conventional UT because:

- *Contact surfaces of PA's probes wedges are wider compared to conventional UT*
- *It's more critical to ensure a constant wetting ability*
- *PAUT inspections are mostly recorded and coupling consistency has to be guaranteed*