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UNDERWATER ULTRASONIC PEENING OF WELDED ELEMENTS AND STRUCTURES

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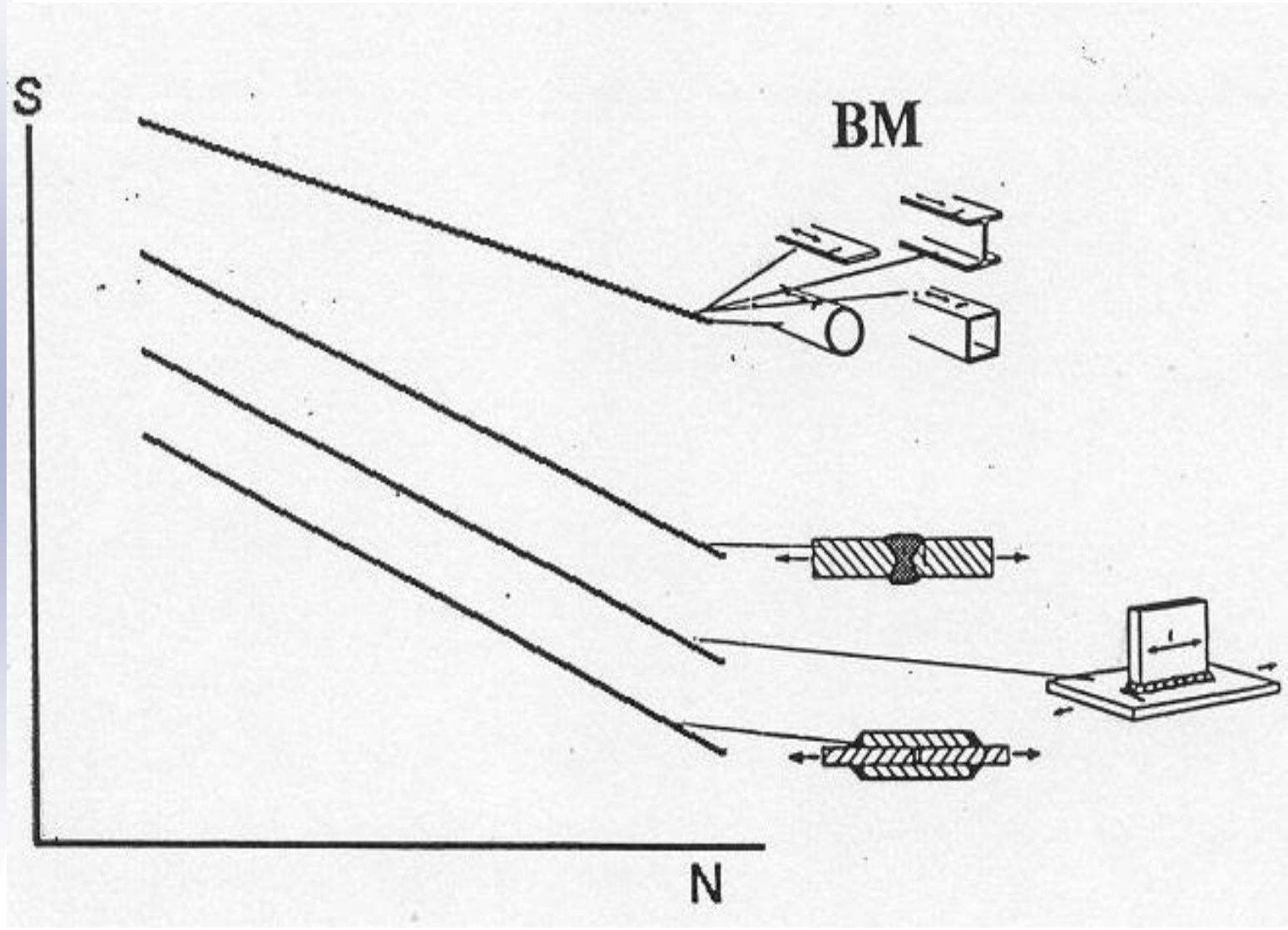
Outline

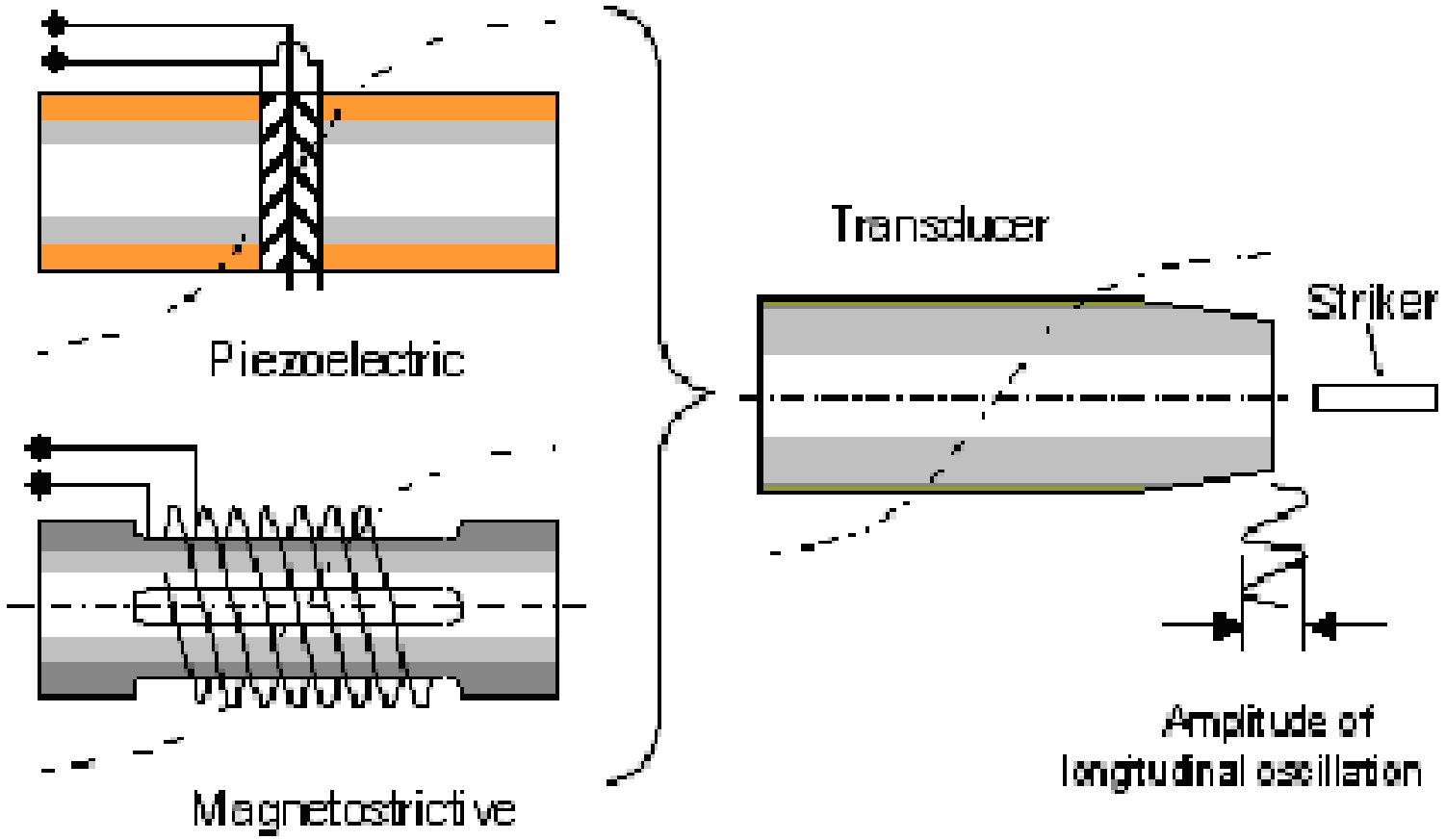
1. Introduction
2. Principles, Technology and Equipment for Ultrasonic Peening (UP)
3. Application of Underwater Ultrasonic Peening (UUP) for Fatigue Improvement of Welded Elements
4. Summary

Fatigue Strength of Base Metal (BM) and Welded Elements



Technology and Equipment for Ultrasonic Impact Treatment or Ultrasonic Peening (UIT/UP)

Schematic view of transducers for UIT/UP using piezoelectric and magnetostrictive approaches



Replaceable working heads for different industrial applications

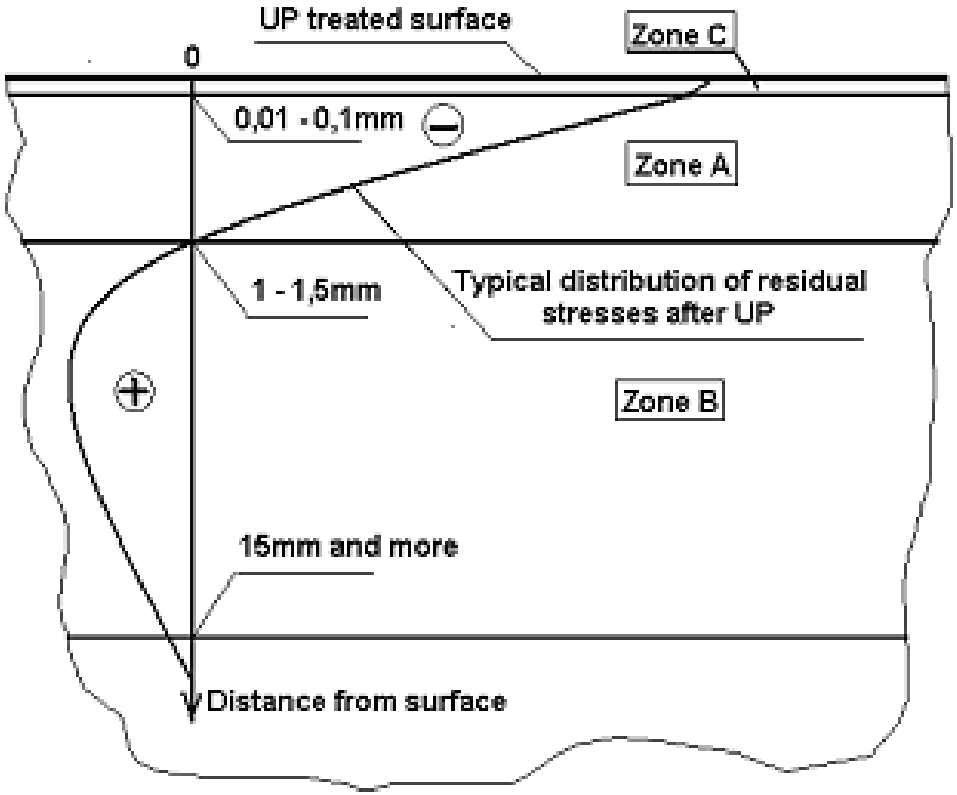
PRINCIPLE OF ULTRASONIC PEENING

The technique is based on the combined effect of:

1. **High frequency impacts of the special strikers**

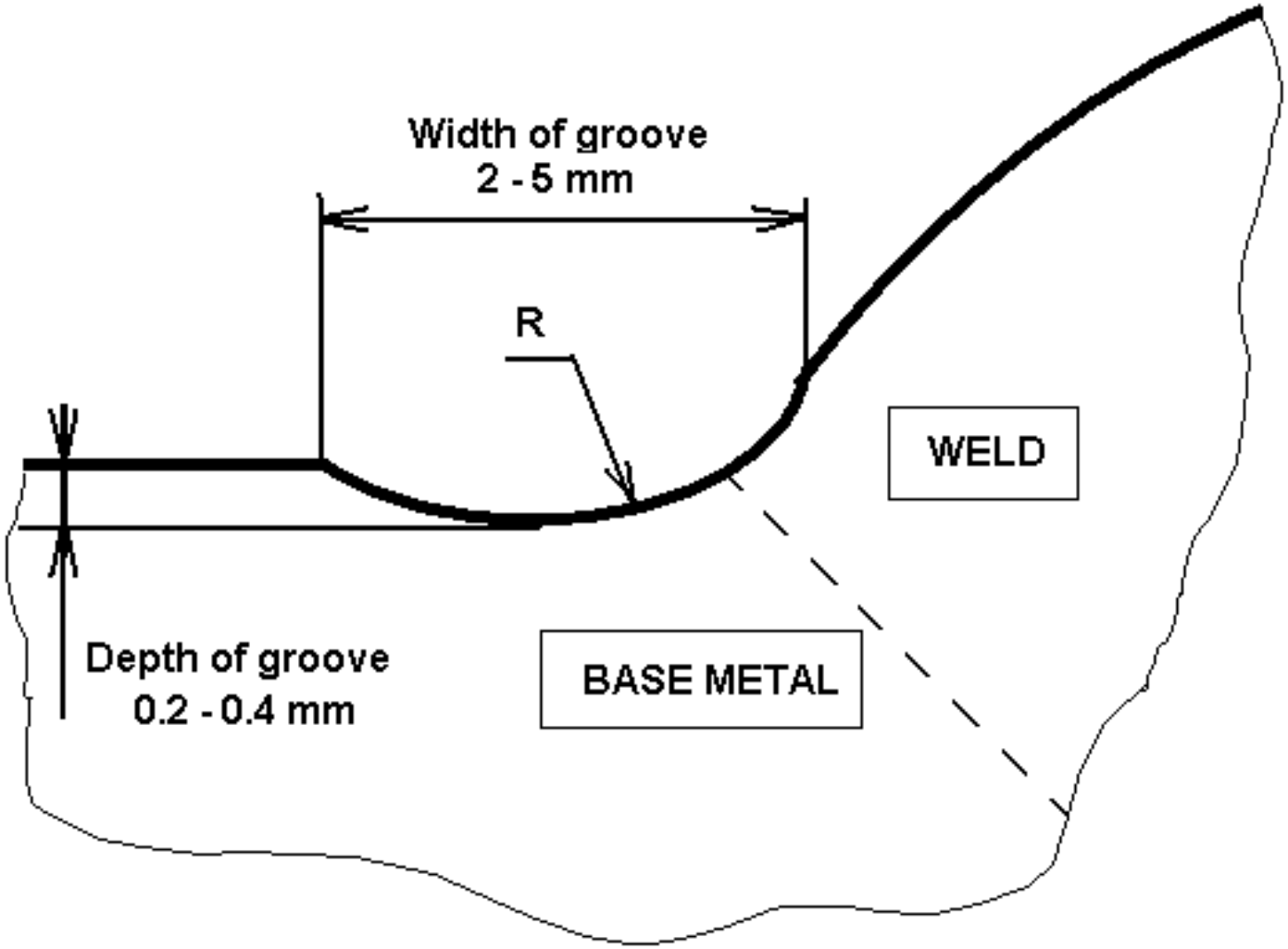
2. **Ultrasonic oscillation in treated material**

MATERIAL/PART IMPROVED BY UP



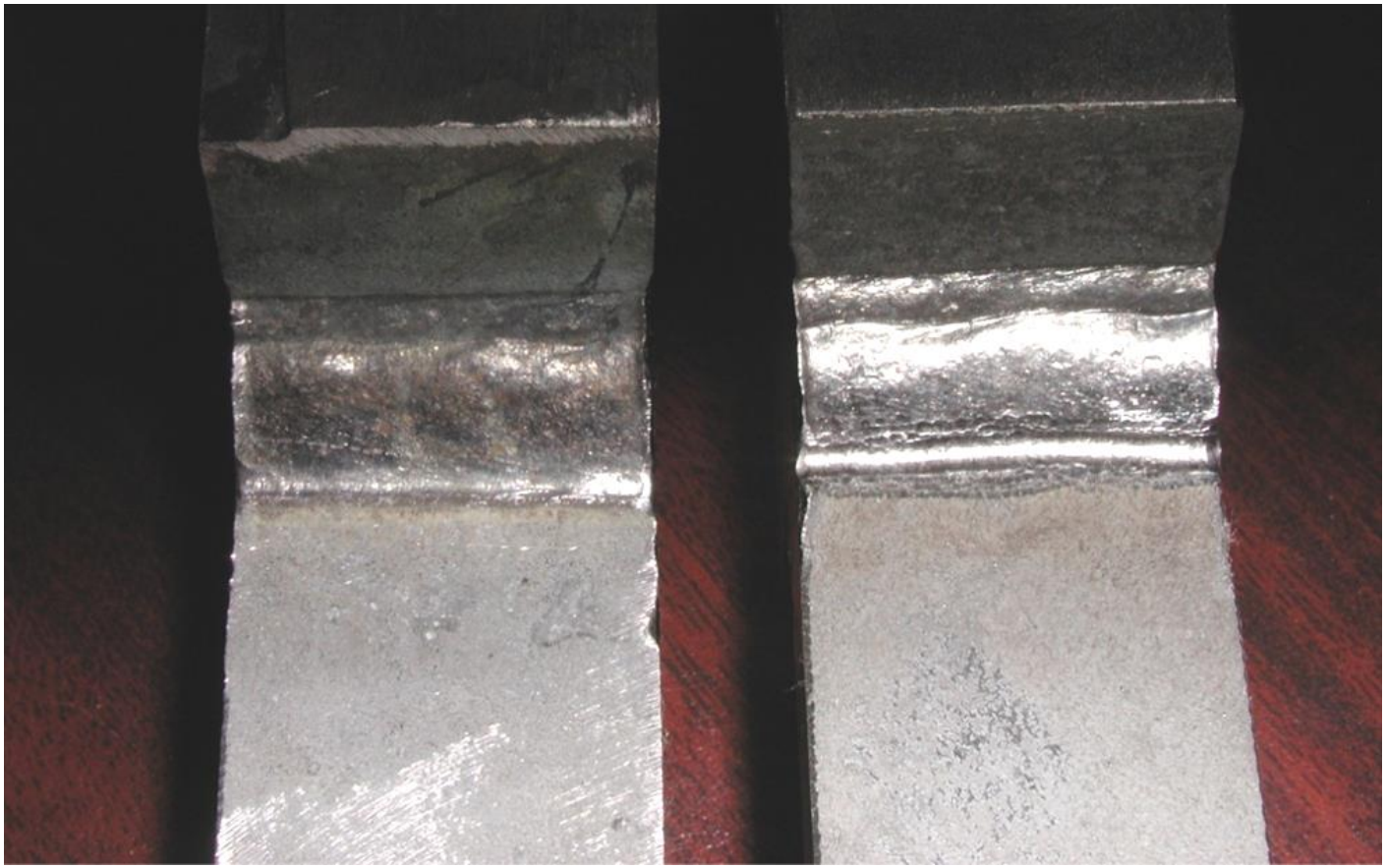
Zone	Description of zone	Penetration (distance from surface), mm	Improved characteristics
A	Zone of plastic deformation and compressive residual stresses	1 –1,5 mm	Fatigue, corrosion, wear, distortion
B	Zone of relaxation of welding residual stresses	15 mm and more	Distortion, crack propagation
C	Zone of nanocrystallization (could be produced at certain conditions)	0,01 – 0,1 mm	Corrosion, wear, fatigue at elevated temperature

Profile of weld toe improved by Ultrasonic Impact Treatment (UIT/UP)



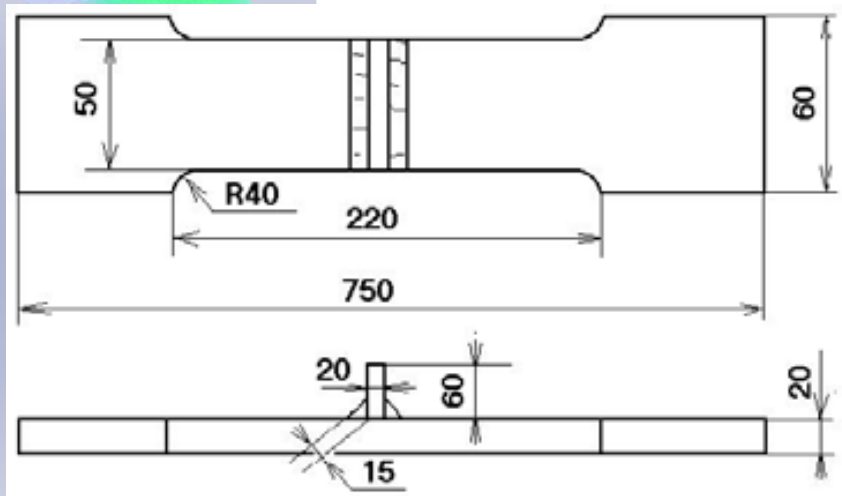
The view of the butt welds in as-welded condition (left side sample) and after application of UP (right side sample)

The view of the fillet welds in as-welded condition (left side sample) and after application of UP (right side sample)

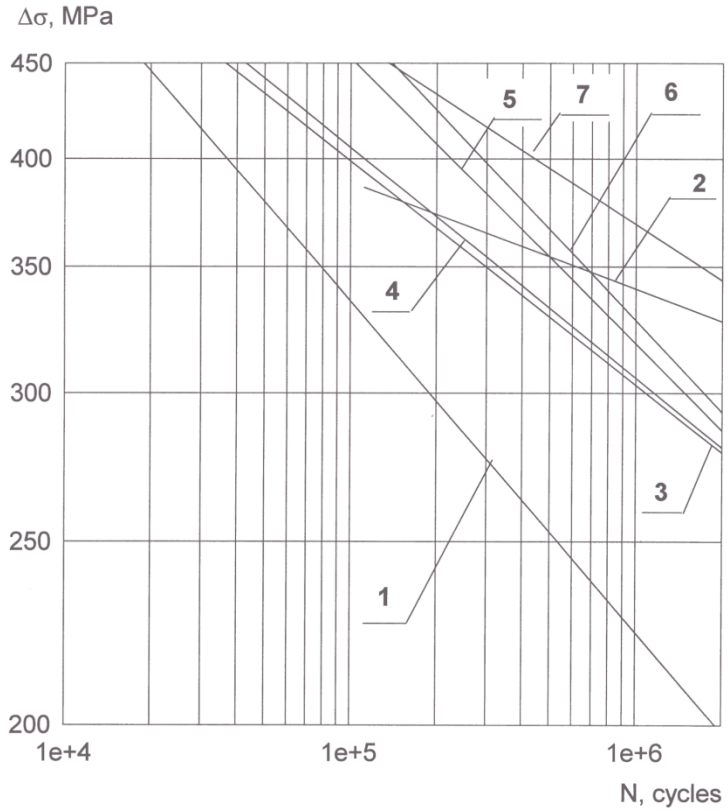


Comparison of Ultrasonic Peening and Other Fatigue Life Improvement Methods

Data from IIW Document XIII-1817-00 on fatigue testing of welded samples made from steel WELDOX 420 (yield strength - 460 MPa, ultimate strength – 570 MPa)



Specimen for fatigue testing N, cycles1e

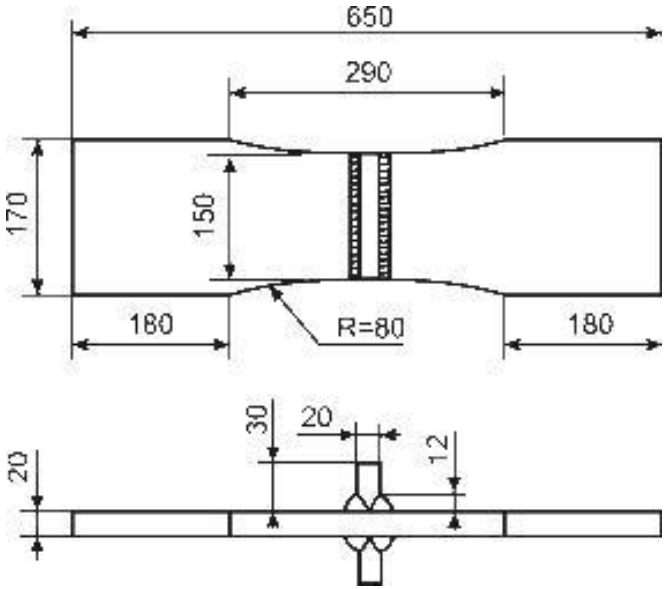


Series 1 – as welded (m = -3,6867);
Series 2 – UIT treated (m = -17,5413), 5 and 3mm pin diameter;
Series 3 – hammer peened (m = -8,3701);
Series 4 – shot peened (m = -8,1321);
Series 5 – TIG dressed (m = -6,5539);
Series 6 – TIG dressed and UIT treated (m = -6,2090);
Series 7 – UIT treated (m = -9,7799), additional series, 3mm pin diameter.

Effectiveness of UIT/UP applied after welding and 50% of expected fatigue life of welded elements

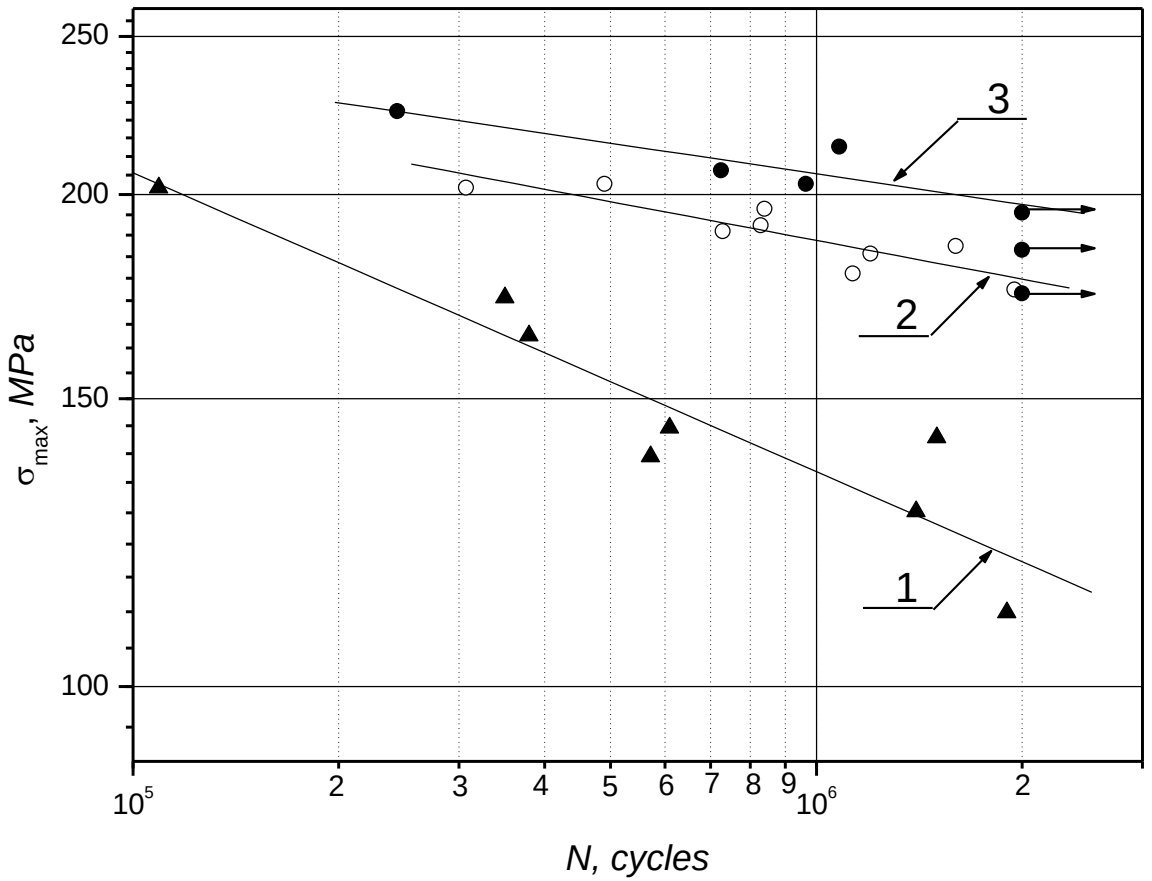
Three series of welded samples were subjected to fatigue testing:

1 – in as welded condition,
2 – UP was applied before fatigue testing,
3 – UP was applied after fatigue loading with the number of cycles corresponding to 50% of the expected fatigue life of samples in as-welded condition.



The general view of welded sample for fatigue testing

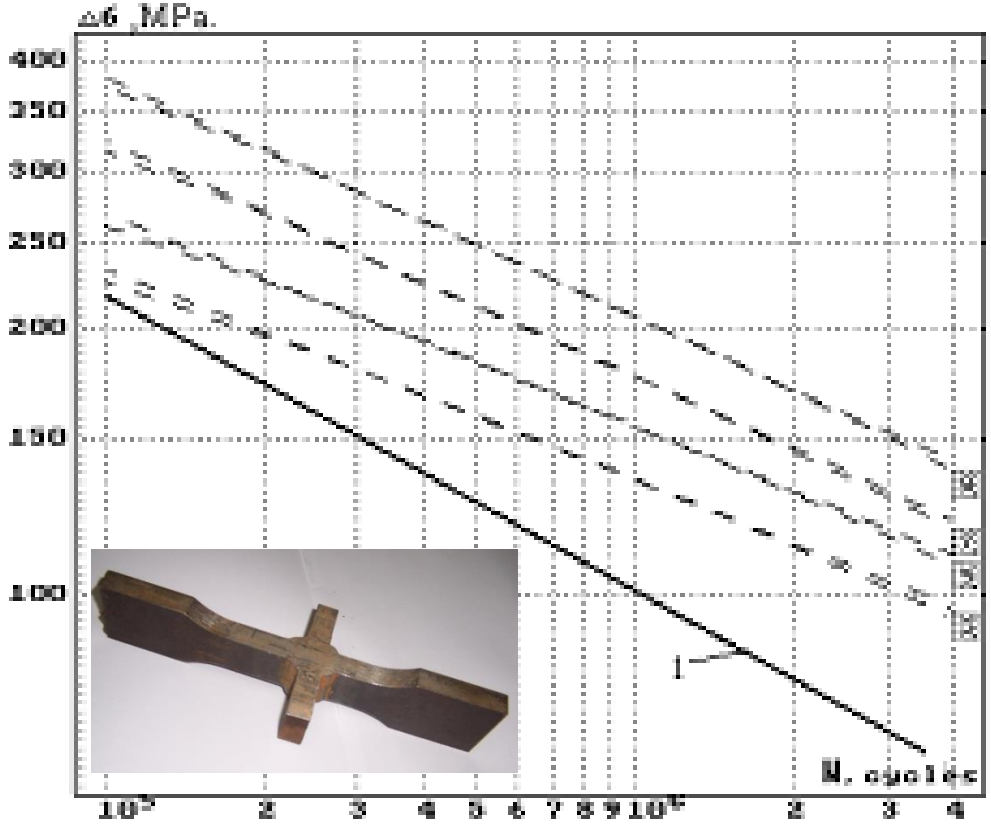
Fatigue Improvement by UIT/UP



Fatigue curves of welded element (transverse non-load-carrying attachment):
1 – in as welded condition,
2 – UP was applied before fatigue testing,
3 – UP was applied after fatigue loading with the number of cycles corresponding to 50% of expected fatigue life of samples in as-welded condition.

UIT/UP of High Strength Materials

The higher the mechanical properties of the materials – the higher the efficiency of UIT/UP



1 - in as-welded condition for all types of steel

3, 5, 7 and 9 - after application of the UP to Steel 1, Steel 2, Steel 3 and Steel 4

Rehabilitation of Welded Bridge (Indiana, USA) by UIT/UP

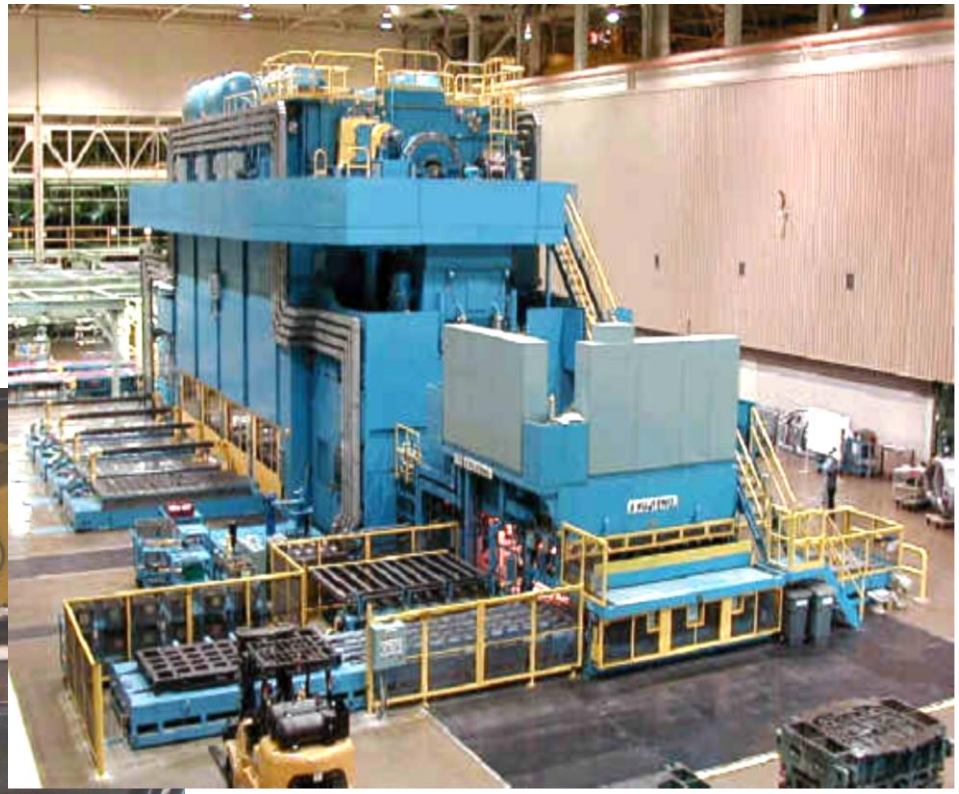
Total Length of UP Treated Welds - 500 meters
Number of UP Treated Welded Elements -2500

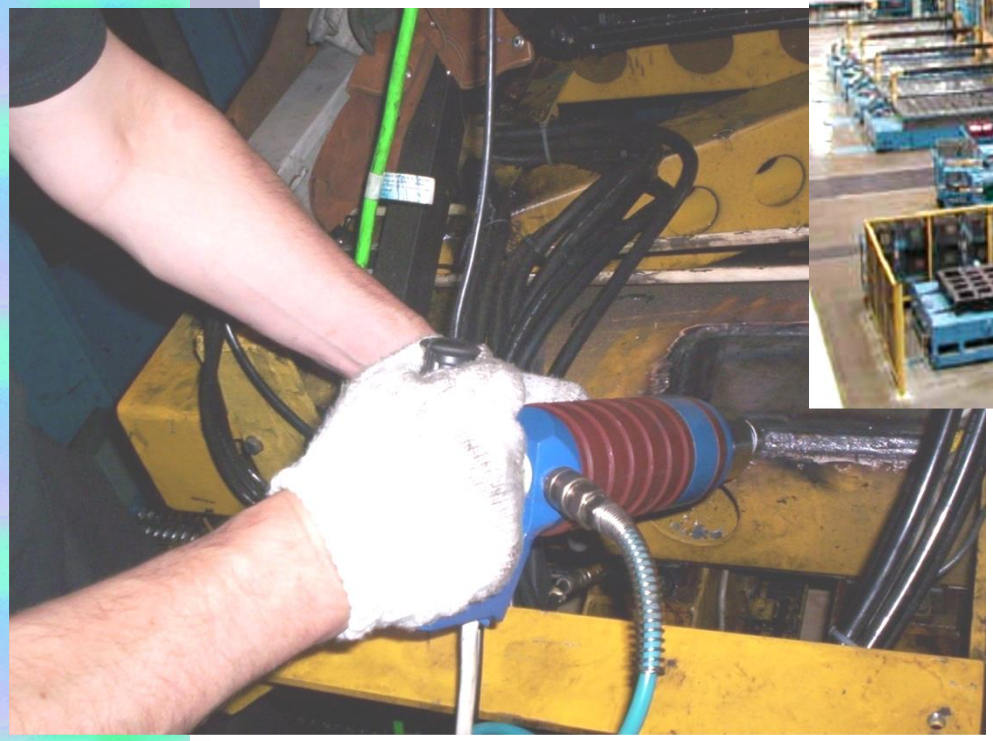
Application of UIT/UP for Rehabilitation of Mining Equipment

UIT/UP of Fatigue Critical Welds of a Grinding Mill

Total Length of Treated Welds – 250 meters

Application of UIT/UP for Rehabilitation of Stamping Equipment





UIT/UP of a Welded Reinforcement Plate

Application of UIT/UP for Fatigue Improvement of Large Welded Aluminum Panels

The new system UltraPeen®
with easy replaceable working heads
for Underwater Ultrasonic Peening (UUP)

Testing of New System for Underwater Ultrasonic Peening (UUP)

Depth – 30 meters

Material and Samples for Fatigue Testing

Material: CCS E36 Steel Plate For Shipbuilding

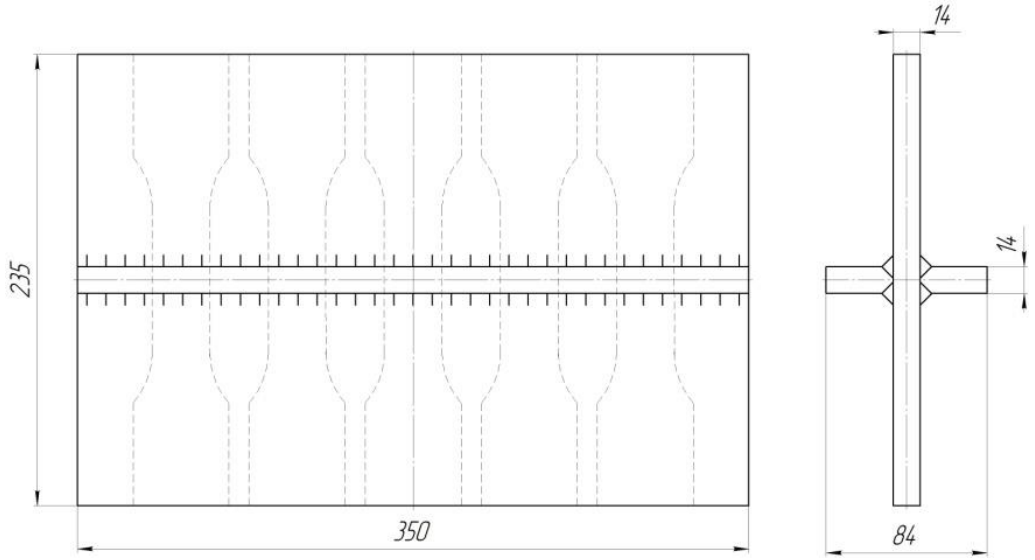
Typical Applications:

CCS E36 marine steel plates are used in manufacturing hull, maritime oil extraction drilling platform, platform tube junction and other structural components

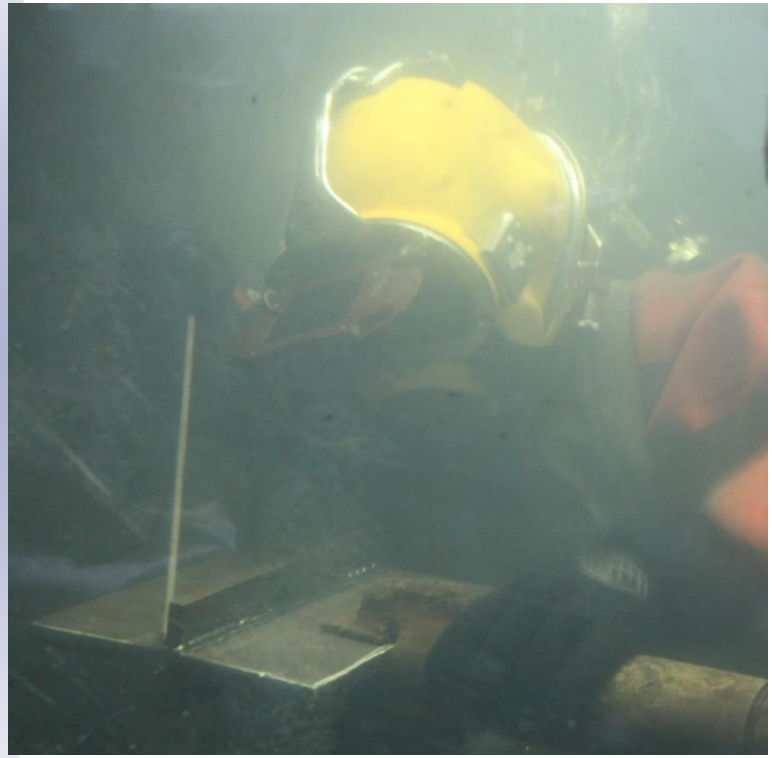
Chemical Composition and Mechanical Property:

Grade	Chemical Composition(%)							
	C≤	Mn	Si	P≤	S≤	Al(cid)≥	Cu≤	Mark
CCS E36	0.18	0.90-1.60	0.10-0.50	0.035	0.035	0.015	0.35	CCS/E36

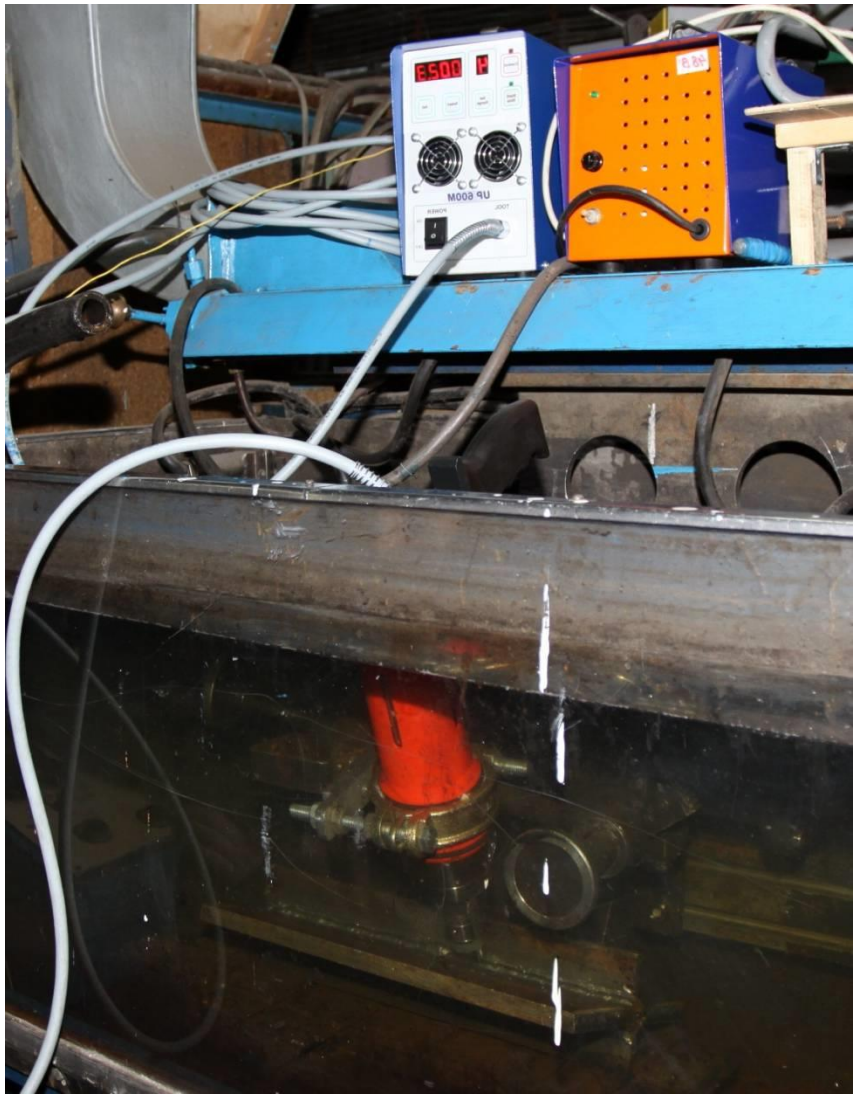
Ultimate Strength 576.7 MPA	Yield Strength 428.6 MPA



The process of underwater welding and Ultrasonic Peening by using UltraPeen® system



Underwater Ultrasonic Peening of Welded Element (automatic)



View of the welded plate after UUP

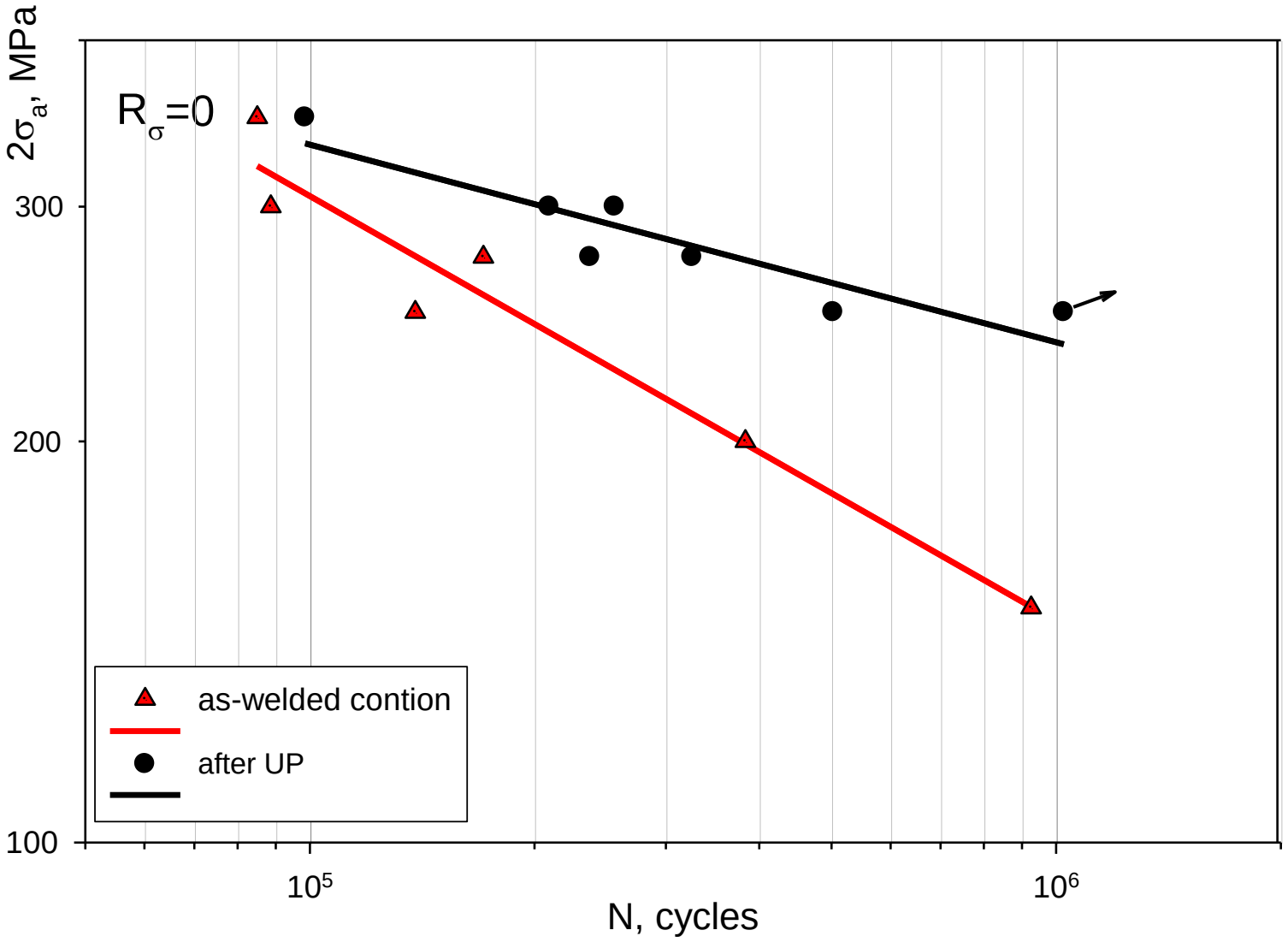
View of the welded samples for fatigue testing

(left – in as-welded condition, right – after UUP)

Fatigue testing of welded samples

Axial loading, R=0,1

Fatigue Improvement by UUP



Summary

1. The fatigue testing of welded specimens showed that the UIT/UP is the most efficient improvement treatment as compared with traditional techniques such as grinding, TIG-dressing, heat treatment, hammer peening, shot peening or application of LTT electrodes.

Summary

2. The results of the fatigue testing showed that the developed technology and equipment for Underwater Ultrasonic Peening (UUP) provides significant fatigue improvement of welded elements similar to what is observed for UP in air. The fatigue life of welded samples increased under the action of UUP in 4-5 times depending on the level of applied stresses.

Thank you for your attention

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