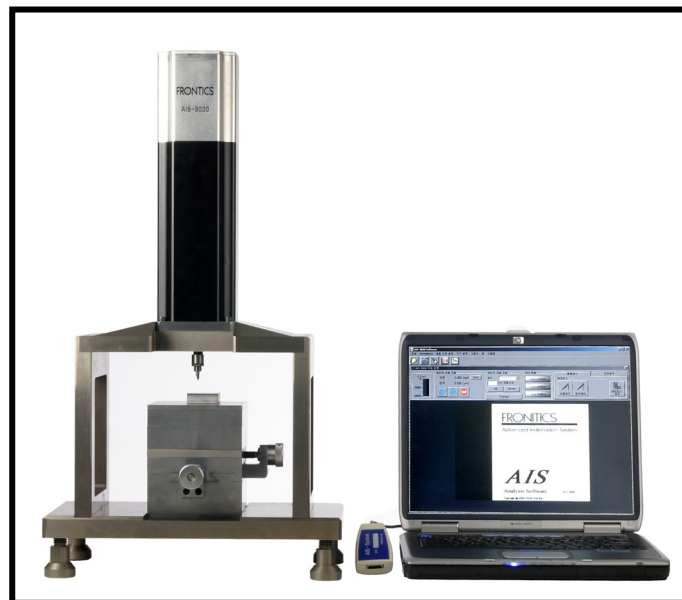


AIS3000



Advanced Indentation System
3000

www.frontics.com

Measurement of residual stress on welded material using AIS 3000

AIS3000 (Advanced Indentation System 3000) is portable indentation system for non-destructive residual stress evaluation. Residual stress in a material shifts the indentation load-depth curve. The load-depth curve shifts to right or left side when tensile or compressive residual stress is applied, respectively. The lower load is needed to reach the same depth when the tensile residual stress is applied, and the higher load when compressive residual stress. Therefore, AIS3000 can measure quantitative values for residual stress if it know the relationship between the load gap and residual stress.

(1) Introduction

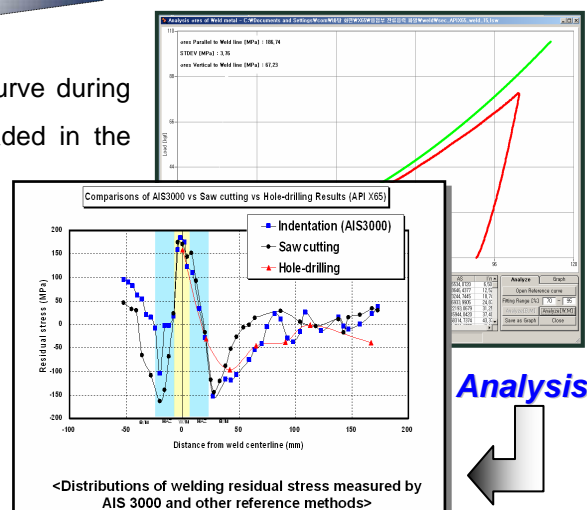


Portable Residual Stress Measurement

AIS3000 is made up of a main body and a laptop with software. The AIS3000 can help users perform fast and easy tests with wireless communication module between the laptop and main body. And it is light and miniaturized for easy and fast transportation and installation.

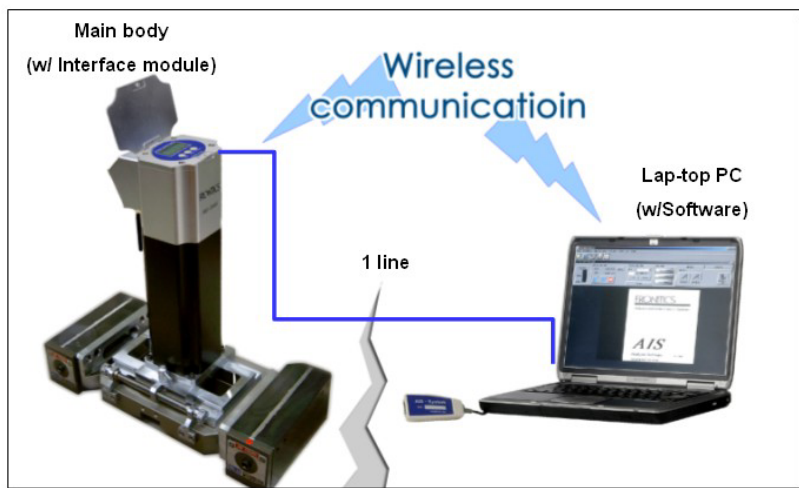
**In-situ testing &
Residual Stress**

AIS3000 can obtain in-situ indentation load-depth curve during indentation test. Through the software program loaded in the laptop PC, residual stress. In addition, changes in residual stress such as weldment/HAZ/base metal and local material degradation can be analyzed immediately by the superposition of the obtained curves.



(2) AIS3000 Hardware

► Specifications of AIS300 Hardware



	Specifications
AIS3000 Components	Main body(w/Interface module) Lap-top PC (w/Software) Wireless / 1 line
Main body ↕ Receiver (max. length)	<u>Wireless module or 1 cable</u> Wire: 100m Wireless: 1km

► System Feature of AIS3000 Hardware

Protective, compact system

- ✓ Height 43cm, Weight 7kg (Lab / Portable)
- ✓ In-situ data analysis using lap-top PC
- ✓ Miniaturization of Interface
- ✓ Freshly external by lightweight coating
- ✓ Watertight, crushproof and dustproof case



Convenience function

- ✓ Wireless communication model or
One-line communication for system control
- ✓ Remote control function
- ✓ Direct control & Module monitoring at LCD Panel
(Module monitoring on the top of main body)
- ✓ Portable battery available (10hr)
- ✓ Various diameter of indenter tip



< Wireless communication >



< Remote control and LCD >



< Portable battery >

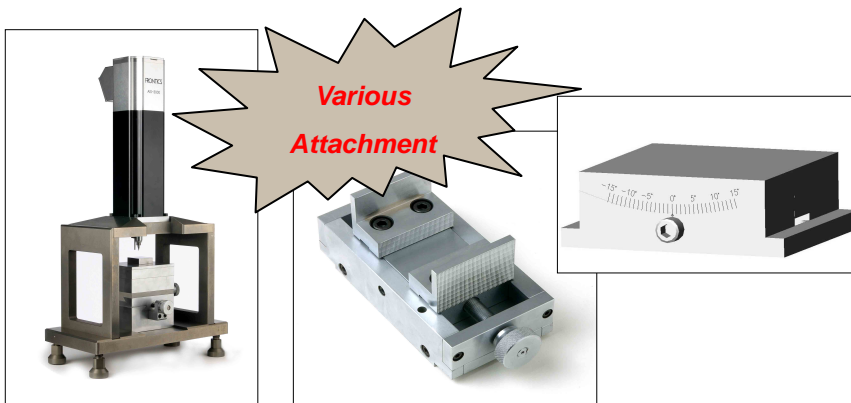
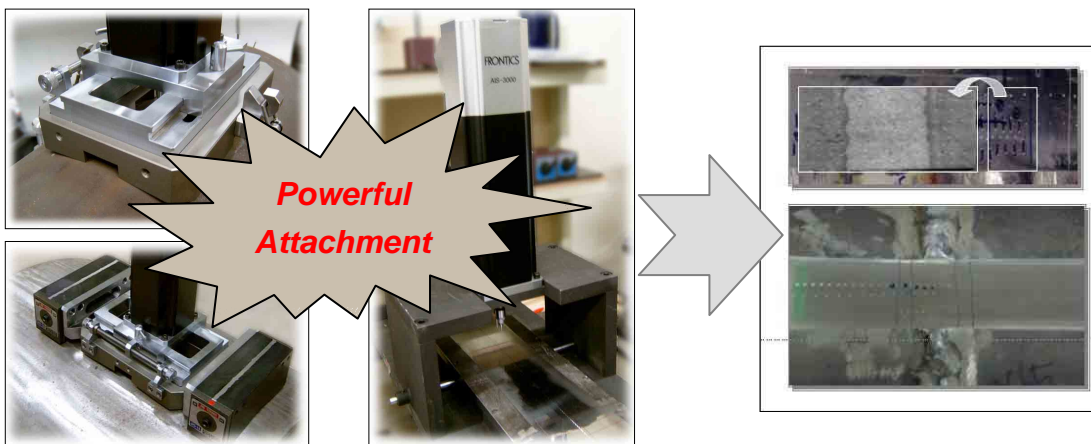
High-performance

- ✓ Using high-performance sensor
- ✓ Automatic sensing of initial contact point
- ✓ Precision speed control
- ✓ Measurable limits of 0.06kgf & 0.1 μ m
- ✓ Over-load prevention function
- ✓ Limit function for Up /Downward

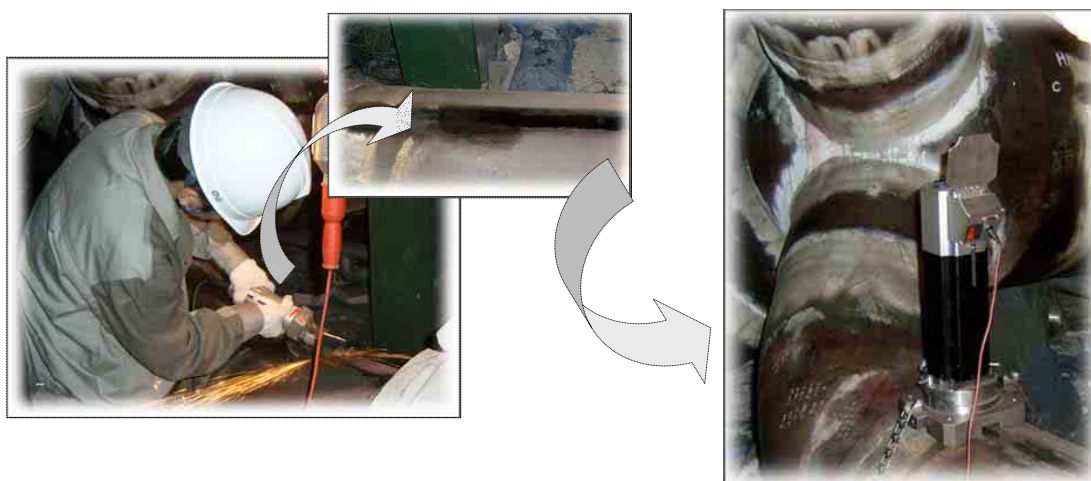
Stability & Powerful attachments

- ✓ Micro-motion dovetail slider (w/Multi-point Indentation)
- ✓ Easy and Fast transportation & Installation
- ✓ Various system fixtures (Lab. / Field scale)
 - Multi-curve magnet, Plat magnet, Light-weighted mechanical chain
 - U-block, V-block ($\frac{3}{4}$ ~ 6 inches)
 - Micro-positioning stage & Swivel mount for lab test

<Laboratory>



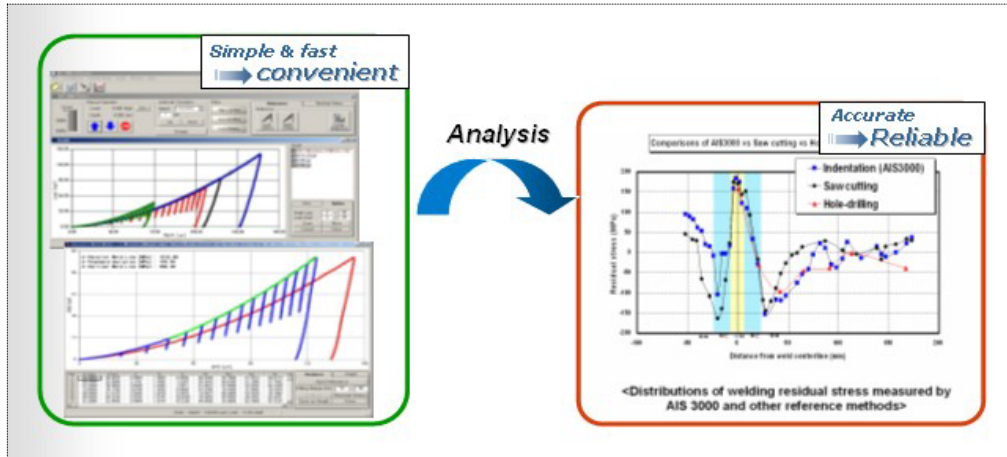
<Field>



☒ Power plant facilities under in-service

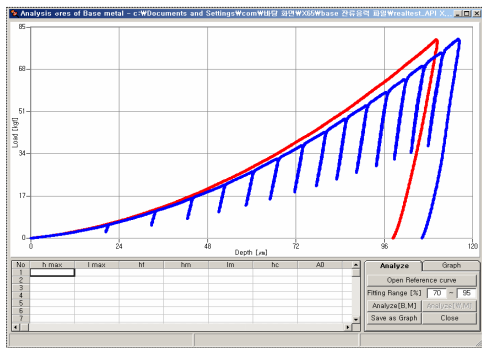
(3) AIS3000 Software

► Analysis schematic of AIS300 Software



► System Feature of AIS3000 Software

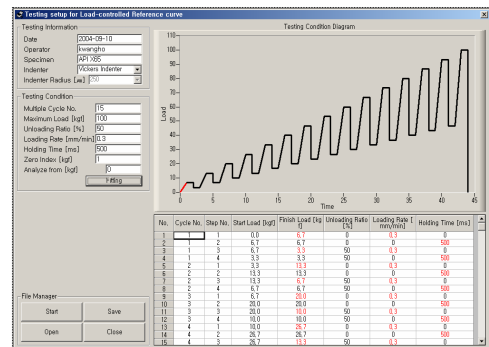
User-friendly type S/W program



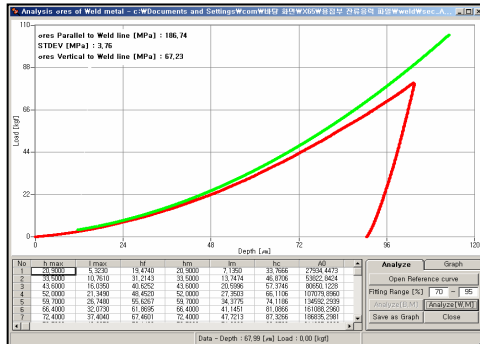
- ✓ Easy operation and data analysis based on Window system
- ✓ Real time indication of load and depth
- ✓ Direct data analysis with data acquisition
- ✓ Fast acquisition of residual stress

Free setting of Experimental Conditions

- ✓ Available selection of load control and displacement control experiment
- ✓ Easy to save and load the existing experiment condition
- ✓ Easy to edit maximum load(depth), load reduction rate, indentation speed, load holding time and etc.



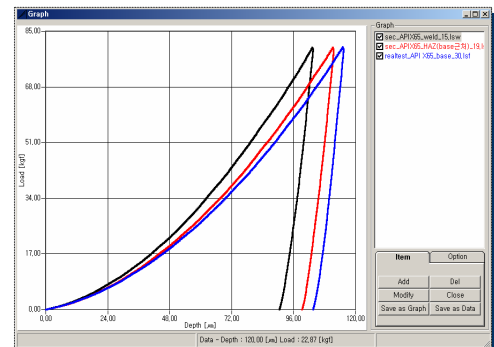
Accurate, Easy and Fast data analysis



- ✓ Accurate evaluation of residual stress based on advanced indentation technique
- ✓ Reproducible residual stress results by mechanical testing method
- ✓ Fast data analysis directly after testing
- ✓ Available magnification of local region of curve
- ✓ Easy operation procedures for non-experts

Load-depth curve overlap

- ✓ Simultaneous comparison of each position stressed curve (load-depth curve)
- ✓ Offering of BMP and text file for user convenience
- ✓ Enable to investigate load-depth curve change with position
- ✓ Free magnification and setting of fitting range



(4) Verification of measured residual stress

The residual stress measured by advanced indentation test is compared with the residual stress measured by hole-drilling and saw-cutting which are generally used for welded material. They show good consistency, especially in the highest tensile residual stress region which is the weakest region in welded material.

► Schematic diagram of specimens

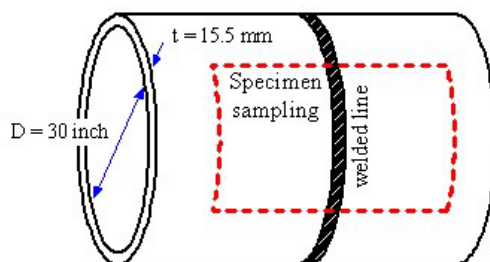


Fig.1 schematic diagram of pipeline

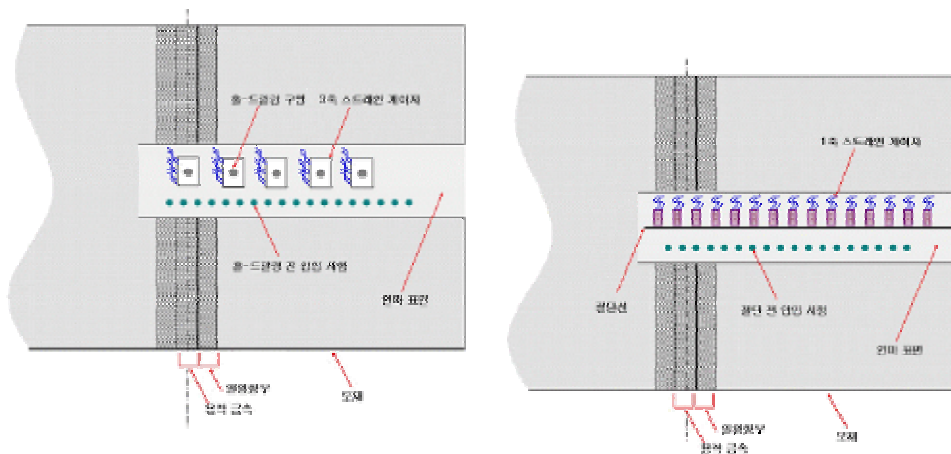


Fig.2 schematic diagram of specimens

► Testing condition

Material

✓ API X65 - 30inch (15.5t)

Preparation for indentation testing (w/surface treatment)

✓ 24inch pipe with centered (Fig.2)

- ✓ 25mm welded metal and 9mm microstructure changed heat affected zone (Bead removal)
- ✓ Jointing screws for fixing to testing base
- ✓ Grinding with #1000 emery paper & Nital etching

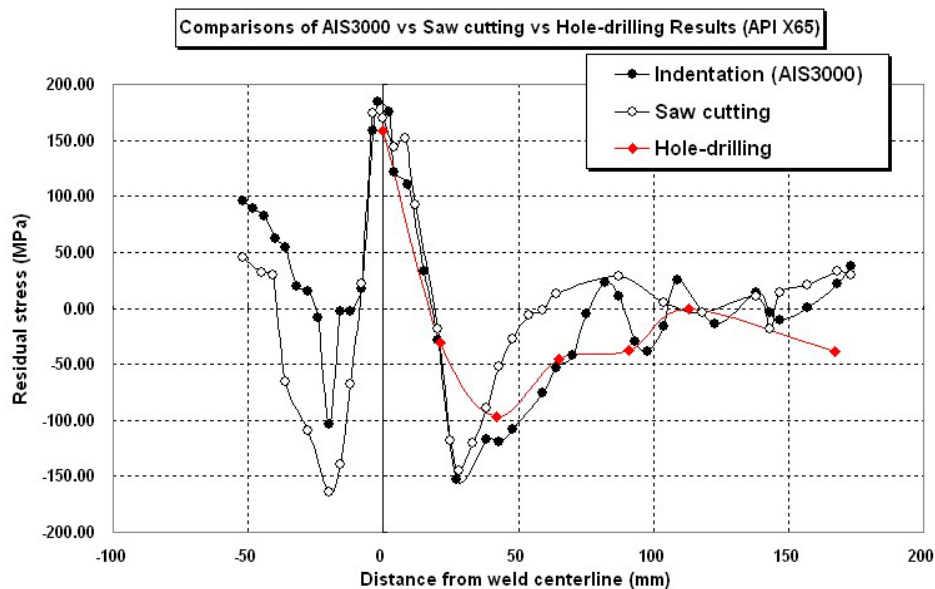
Welding procedure

- ✓ V-groove welding
- ✓ GTAW + SMAW
- ✓ ER70S-G, E9016-G
- ✓ Preheat: 100 , No PWHT
- ✓ Amp./Volt.:80 ~ 130A/12-23V

► **Indentation testing conditions**

- ✓ Maximum load: 80 kgf
- ✓ Indenting speed: 0.3 mm/min
- ✓ Holding time: 500 ms
- ✓ Zero index: 1kgf

► **Testing results**

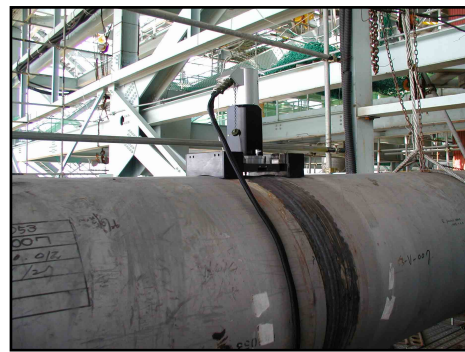


(5) Applications using AIS3000

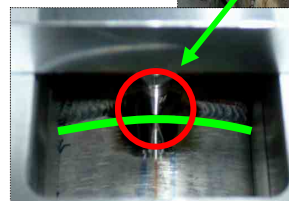
► Powerful Application in Field and Laboratory

- ✓ Evaluate welding residual stress of structures & facilities under construction / in use
- ✓ Evaluate welding residual stress of specimen in laboratory
- ✓ Evaluate residual stress in coating and plating layers

Field scale



< Power plant facilities under-Construction structure >

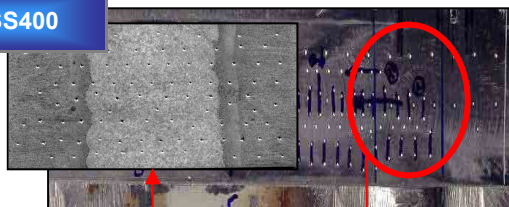


<Residual stress at fusion line of near HAZ >

Lab scale

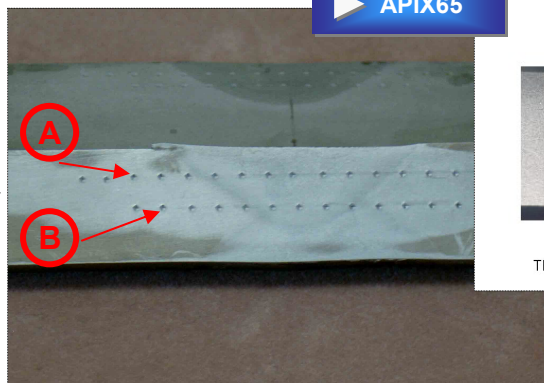


▶ SS400



Annealing

<Indentation array for residual stress measurement>



▶ APIX65

Steel Weldment

- Double Sided Weld -

Top Bead

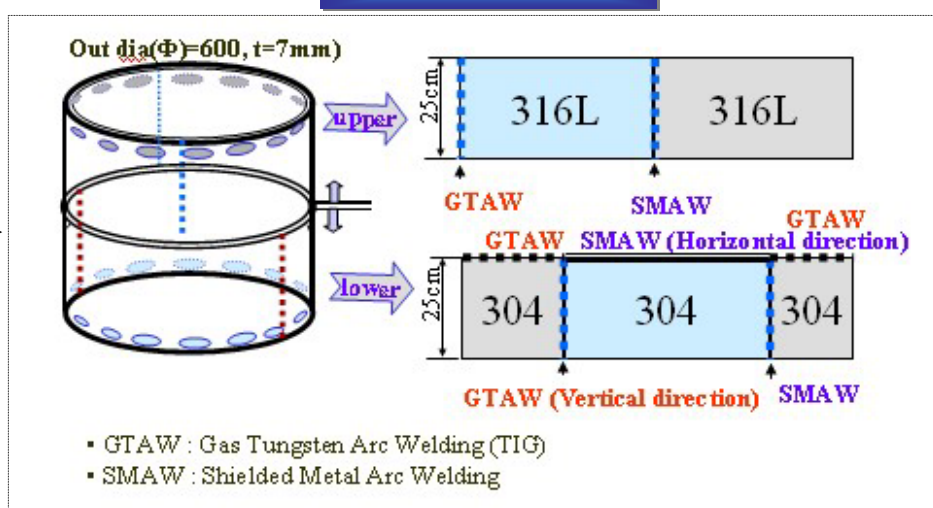


Bottom Bead

Thickness: ~4mm

< Mapping graphic image of whole weldment area at double sided weld>

▶ 304/316 welding joint



< Indentation of transverse direction of welding line at centerline >