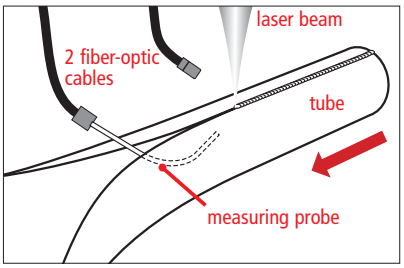
PROMETEC®
Monitoring Solutions

Monitoring of Laser Welding
by Measurement of Plasma Radiation

Plasma Monitor PM 7000

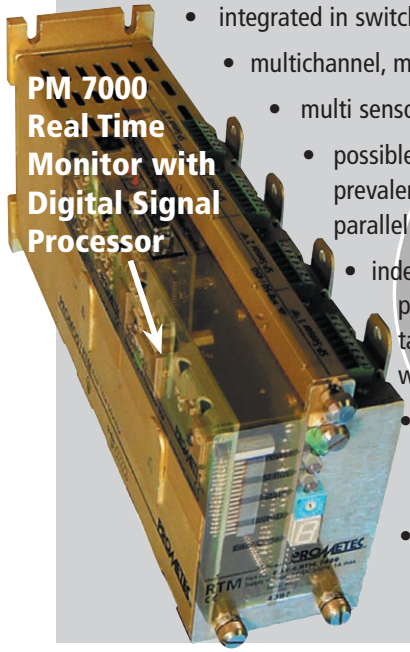


Example: simultaneous monitoring of two welding points or the top and bottom of a weld capillary. Application: endless welding of pipes.

Fast and secure monitoring of laser process quality by the detection of:

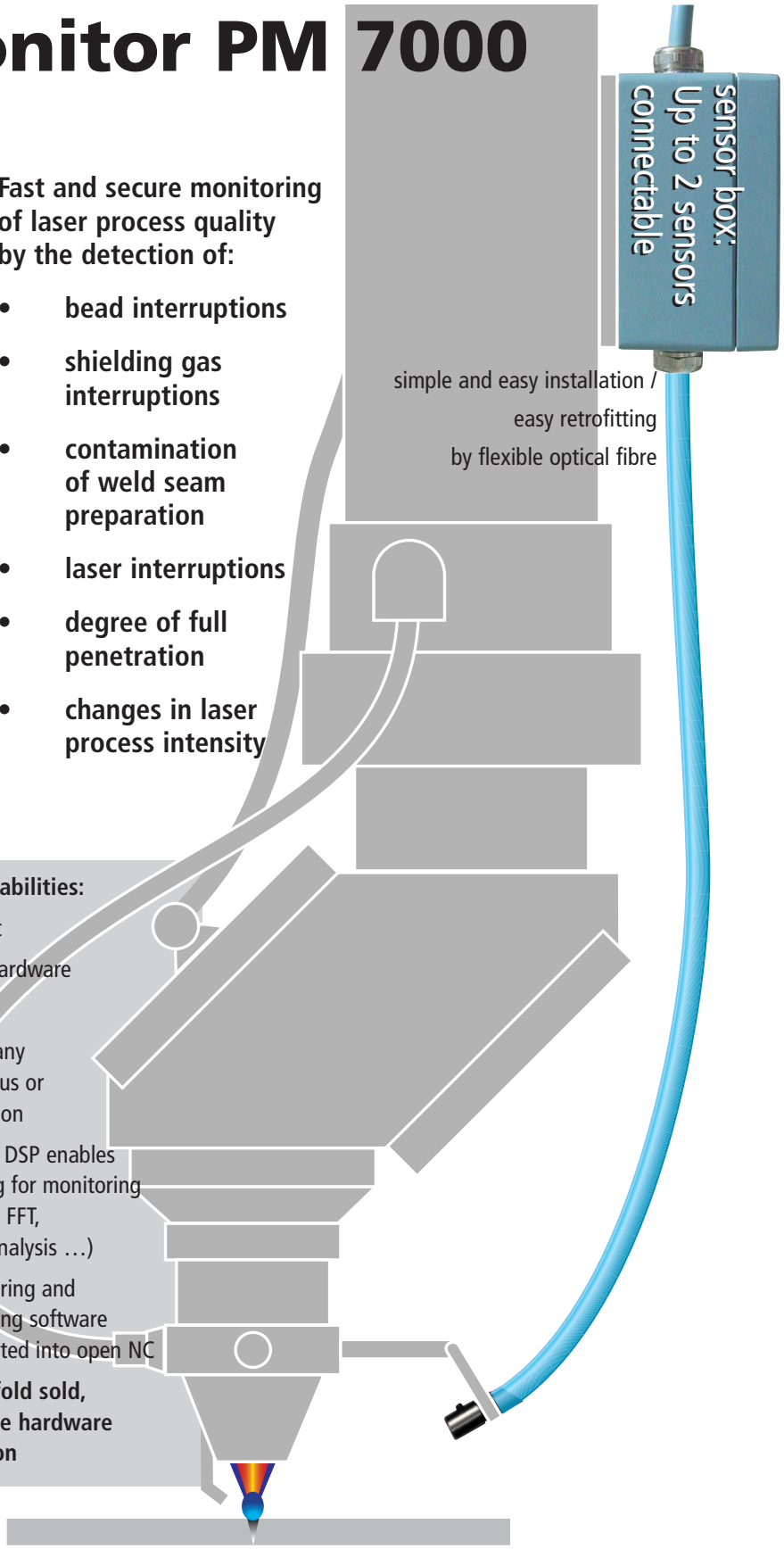
- **bead interruptions**
- **shielding gas interruptions**
- **contamination of weld seam preparation**
- **laser interruptions**
- **degree of full penetration**
- **changes in laser process intensity**

IN PROCESS MONITORING



Monitoring hardware concept and capabilities:

- integrated in switch cabinet
- multichannel, modular hardware
- multi sensor
- possible to use any prevalent field bus or parallel connection
- independent DSP enables processing for monitoring tasks (e.g. FFT, wavelet analysis …)
- monitoring and operating software integrated into open NC
- **1000 fold sold, reliable hardware solution**



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	Welding Monitor PD 2000 spatially resolved (two dimensional) camera based laser process monitoring	**Plasma Monitor PM 7000** one dimensional photo detector based laser process monitoring
General Attributes		
Price (in 2005)	**25,000 up to 35,000 €**	**approx. 15,000 €**
In Process Monitoring	**Yes**	**Yes**
Suitability for CO_2-, Nd:YAG-, Fiber- and Diode lasers	**Yes**	**Yes** (CO_2; others conditional)
Coaxial orientation of the sensors to the laser possible	**Yes**	**Yes**
Off-axis orientation of the sensor to the laser possible	**Yes**	**Yes**
Transparent generation of monitoring signals	**Yes**	No
Monitoring Features	Simultaneous monitoring/differentiation of up to 8 process- or weld-characteristics for one process	Simultaneous monitoring of up to 4 photo detector signals
Sensors retrofittable on laser optics	**Yes**	**Yes**
Multi channel capabilities	Up to 2 asynchronously running laser stations can be monitored with one system (one common machine control).	Up to 4 laser stations can be simultaneously monitored by one system (one common machine control).
Communication with the machine controls	Via field bus or parallel interface	Via field bus or parallel interface
Ease of assessment of the suitability of the systems for specific monitoring tasks	Process deviations are made visible in film. Therefore these deviations can be evaluated and monitored ("what you see is what you get").	The monitoring capabilities of the system are defined by previously empirically ascertained results.
Observable spectral range / time resolution		
Plasma radiation	**Yes** (however usually not required)	**Yes**
Visible radiation	**Yes**	**Yes**
Limitability of the spectral range with optical filters	**Yes,** possible	**Yes,** necessary
Monitoring frequency	1 to 5 kHz	10 to 100 kHz
Flexibility / complexity		
Hardware	Hardware consists of an industrial PC and a frame grabber for the acquisition of process images.	Compact module for switch cabinet integration. Independent DSP for fast, high quality signal processing (e.g. FFT, wavelet analysis).
Software	On PC: processing of image data using mathematical algorithms suited for the monitoring of specific process- or weld-dimensions.	Integrated on open NC: which hardware capabilities are applied for signal processing to solve the monitoring task at hand (filterations, quotient formation, FFT analysis) is set by means of the operating software.
Spatial resolution of the process zone	**Yes**	No
Direct insight into the physical effects of laser processes and resulting greater process understanding	**Yes**	No
Implementation as tool for process optimization	**High**	Medium
Suitability for the solution of complex monitoring tasks	**High**	Low
Flexibility in application	**High**	Medium
Need of experience for application	**Low**	High
Monitoring capabilities for specific process dimensions (focal position, weld position energy density, welding speed, etc.)	**High**	Low
Monitoring capabilities for weld dimensions (weld depth, degree of weld penetration, weld position, melt pool geometry, humping, spatter, holes, gap in overlap and butt joint)	**High**	Low
Monitoring capabilities for simple effects (bead interruptions, shield gas interruptions, contaminations of the seam preparation, laser interruptions, intensity changes in laser processes)	**High**	**High**
Insensitivity to normal process and ambient disturbances	**High:** process radiation can be limited and analyzed spatially whereby disturbances can be ignored in evaluations so that their effect upon measurements can be limited.	Low: all process radiation is integrated. The effects of disturbances effect the raw signal. The recognition and compensation of these effects at a later stage is difficult.
Documentation of monitoring results	**Comprehensive**	Limited, at present

Monitoring of Machines, Processes, Tools and Lasers
Subsidiary companies and representations in Europe, South-America and Asia
www.prometec.com

Germany (Headquarters)
PROMETEC GmbH
Jülicher Str. 338
52070 Aachen
Phone: +49 241 16609-0
Fax: +49 241 16609-50
prometec-de@prometec.com

USA
PROMETEC Inc.
47711 Clipper Street
Suite 200
Plymouth, MI 48170
Phone: +1 (734) 455 0100
Fax: +1 (734) 451 4654
prometec-us@prometec.com

England
PROMETEC Ltd.
41 Church Street
Birmingham West Midlands
B3 2RT
Phone: +44 7971 475134
prometec-uk@prometec.com

Italy
PROMETEC S.r.l.
Viale Ticino, 54
21026 Gavirate (VA)
Phone: +39 0332-1950049
Fax: +39 0332-744952
prometec-it@prometec.com

Eastern Europe
PROMETEC Bratislava
Šustekova 12
SK 851 04 Bratislava
Slovakia
Phone: +42 1263 531211
Fax: +42 1263 531212
prometec-sk@prometec.com

India
PROMETEC GmbH India Branch Office
#1066, 15th Cross, 25th Main
Banashankari-2nd stage
Bangalore-560 070
Phone: +91 (0)80 2671 2220
Fax: +91 (0)80 2671 2199
prometec-in@prometec.com