

LAND

Ladle Refractory Monitoring Fixed Thermal Imaging Systems

Thermal Imaging for
Continuous Process Monitoring
and Quality Control

AMETEK[®]
PROCESS & ANALYTICAL INSTRUMENTS

The Vessel Manager Ladle Refractory Monitoring System provides an accurate and reliable measurement solution to ensure plant safety and help set maintenance schedules in steel plants across the world.

The use of refractory lined vessels (ladles) to transport molten iron and steel is commonplace in steel plants world-wide. Over time, the refractory condition degrades until it must be re-lined. Traditionally, the timing of these re-lines has been based on previous experience and best practise information from the plant's Refractory Manager. However, this mechanism can be unreliable and break-outs have occurred, causing severe damage to plant, personnel injuries and lost revenue due to production delays.

"A better method is required to ensure that safety is not compromised."

The maintenance of these refractory is a significant contribution to the cost of the production of steel. Monitoring the external temperature pattern of ladles allows the extent and distribution of wear to be assessed. This information can be used to determine re-lining strategy and maximize the utilization of ladles by avoiding excessive lining damage and break-outs.

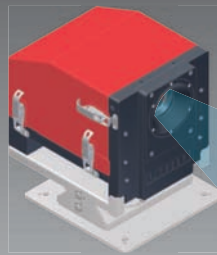
System Overview

Multiple Thermal Imaging Cameras monitor the external shell temperature of ladles as they transfer steel to the continuous casting machines. Each measurement station comprises 1 to 5 cameras mounted to give full coverage of the exterior of a ladle.

The thermal images and temperature data relating to individual ladles are stored, enabling engineers to identify long-term trends and make decisions about the repair and renewal of linings. The integrated image recognition software, using intelligent OCR technology, allows automated long-term trending of all ladles on plant.

Multiple Benefits

Improved Safety: The ladle monitoring system helps improve the safety of the operator and minimises the risk of damage to the plant by monitoring the ladle surface for hot spots and alerting operators before the condition becomes critical.



Key Benefits

- Improved Safety
- Prevention of break-outs
- Extended lifetime of ladle refractories
- Evaluation of different refractories
- Detection of problematic areas
- Cast refractory uniformity



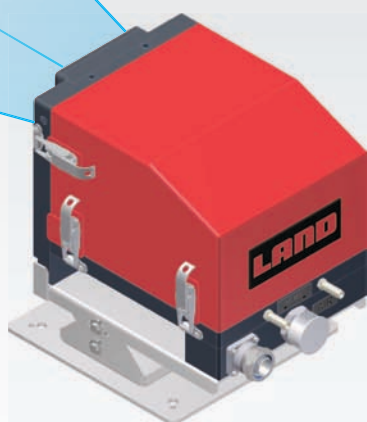
Prevention of break-outs: The prevention of break-outs improves the safety of steel plant personnel. Break-outs occur when the refractory lining of a ladle becomes excessively depleted in a particular area. Vessel Manager detects the abnormal temperature increase caused by this depletion and generates an alarm signifying the need to remove the ladle from production and re-line it.

Extended lifetime of ladle refractories:

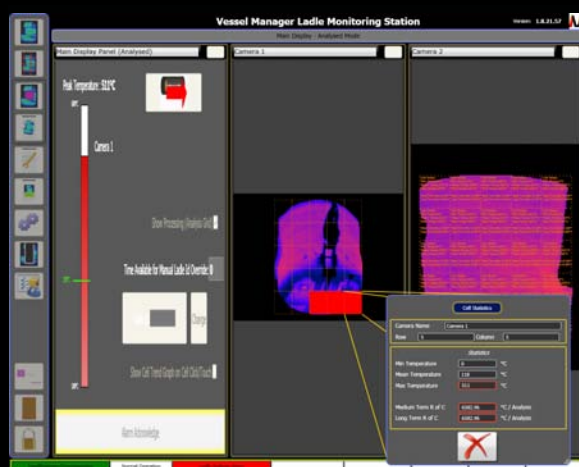
It is common practice to remove a ladle from production to be re-lined after a pre-determined number of "heats". This number is usually generated from the experience of the refractory engineers on site and is, for safety reasons, very conservative, often resulting in unnecessary early re-lines. The Vessel Manager System enables operators to identify which ladles require a full or partial re-line, effectively extended the usable lifetime of the ladle.



Typical operating environment for the Vessel Manager system



Schematic of a typical 5-camera installation

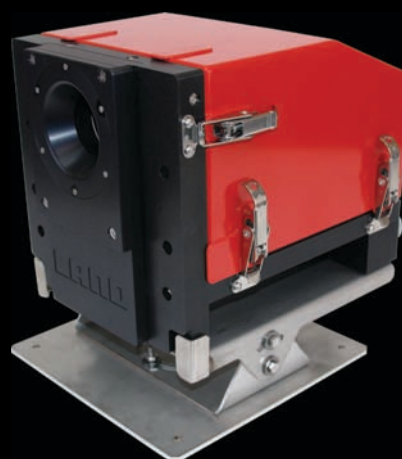


Vessel Manager live display

Evaluation of different refractories: The ability to measure and compare the surface temperatures of several types of ladle allows evaluation of the effectiveness of different refractories.

Detection of problematic areas: Selective or early repairs can be carried out on problematic areas. No need for a more expensive total re-line.

Cast refractory uniformity: If cast refractories are used, incorrect positioning of the casting former can produce a line with varying thickness. Varying thickness can be seen the first time that the ladle is used as a non-uniform external temperature.



Robust protection enclosure, with durable sapphire window

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Vessel Manager Software

Vessel Manager is a comprehensive, application dedicated software system which provides steel plant engineers and managers with the tools to improve plant safety whilst maximising the lifespan of a ladle's refractory. The system monitors the rate of change of temperature over the surface of all ladles on plant. An increase in external shell temperature and accelerating rate of change gives a clear indication of refractory wear, enabling effective reline schedules to be set.

Ladle Recognition

The software features integrated intelligent shape recognition technology, which is configured to identify all the ladle profiles used on plant whilst excluding other elements. This system ensures false alarms are not reported as a result of hot background objects.

Data capture and analysis starts once the software has confirmed the presence of a ladle in the camera's field of view.

Ladle Identification

Vessel Manager stores the temperature data for each individual ladle on plant for long-term analysis and trending. The ladle ID can be determined automatically through OCR (if displayed on the external shell), supplied via an Ethernet connection or input manually by the operator.

Once the ladle has been identified, the temperature data from each thermal imaging camera is analysed.

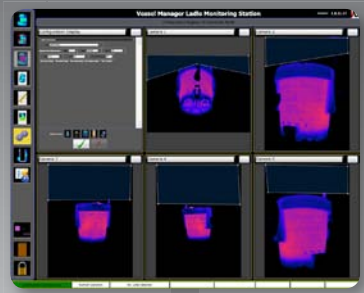
Ladle Analysis

Vessel Manager features a fully configurable analysis system, allowing a grid to be overlaid on the thermal images. Each cell in the grid provides the min/max/mean temperature for that area, along with rates of change, position and camera ID.

The live temperature data from each cell is compared with pre-configured alarm thresholds - any discrepancy between the live data and the predefined limits will raise an alarm.

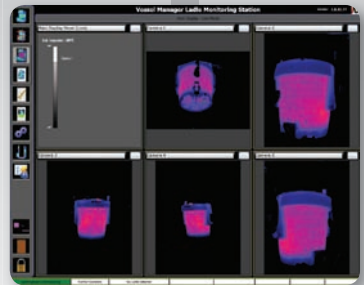
Vessel Manager's on-screen analysis grid clearly highlights the location of the alarm, giving the operator immediate indication of a potential problem. These alarms must be acknowledged by the operator and are then recorded.

How is refractory condition measured?



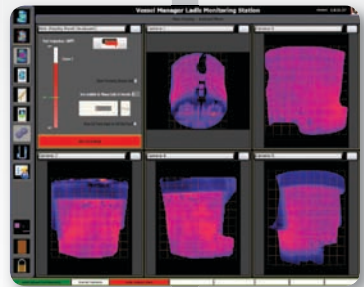
Screen 1

Configuration of the Vessel Manager System.



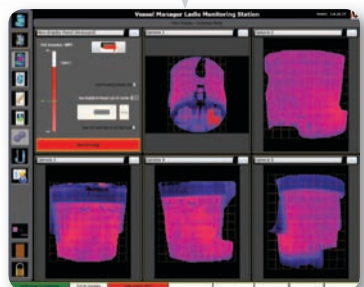
Screen 2

Live thermal image after shape ladle identification and verification has been performed



Screen 3

Analysis grid showing minimum, maximum, mean and rate of change.



Screen 4

System in Alarm showing areas on the ladle exceeding the threshold for rate of change.

Main Display

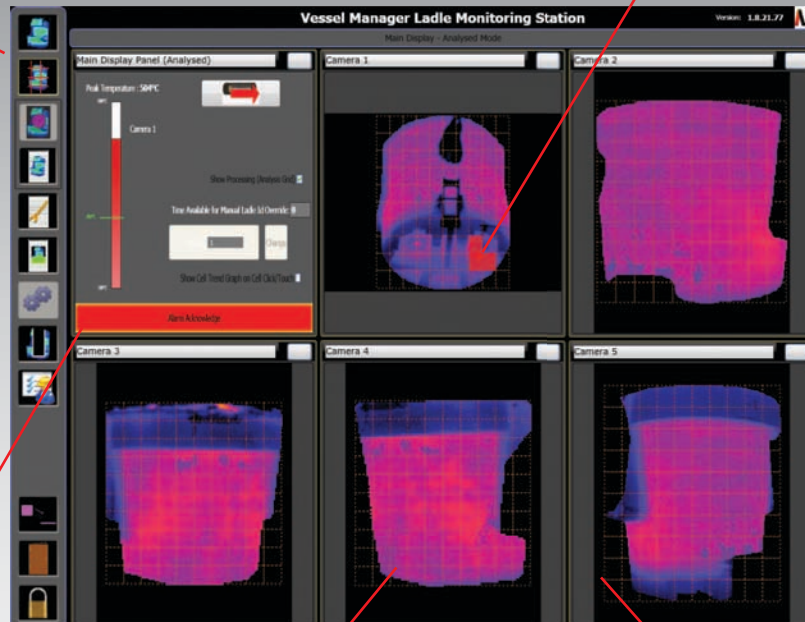
Allows users to observe the critical live and historical information. The display screens shows the live & historical thermal images from all cameras connected with an overlaid analysis grid of alarm levels and rates of change.

Tool Menu

Gives access to all configuration and display screens

Alarm Indication

Shows on analysed thermal image the exact location of the alarm



Alarm

Details of any alarm states.

Analysis Grid

Analysis grid overlaid onto live thermal image to provide min/max/mean and rate of change data.

Main Display

Multi-screen view showing live thermal images from 5 cameras

Key Benefits

- **Cost savings** via maximisation of refractory lining service life.
- **Improved safety for plant personnel.** Gain confidence in plant safety through an integrated, automatic monitoring system.
- **Long Term Trending** of surface temperature changes ensures an orderly predictive and preventative maintenance programme – monitor the number of ladle runs per re-line, see the effectiveness of a fresh re-line and maximise efficiency by ensuring correct pre-heat temperature.
- **Break-out Prevention.** Early warning of developing hotspots, which could lead to molten metal break-out. See hotspots forming, monitor their maximum temperature and rate of change.

Headline Specifications

- 360° image of ladle sides and base (5 camera system)
- Automatic storage of long term trending data
- Display, control and view measurement information from up to five thermal cameras simultaneously
- Import of ladle ID number permits trending of ladle temperature variations, assisting with the generation of maintenance schedules
- Exchange of information via Ethernet links.



**Improve efficiency whilst
ensuring plant safety**

Outline Specifications

	High Range Sensor		Low Range Sensor	
Temperature Range	150 to 600 °C 302 to 1112 °F		50 to 350 °C 122 to 662 °F	
System temperature measurement accuracy (conformity)	±1 % C / ±1 % °F (200 to 600 °C / 392 to 1112 °F specified range)		±1.5 °C (50 to 100 °C) ±1% C (100 to 350 °C) ±2.7 °F (122 to 212 °F) ±1 % F (212 to 662 °F)	
System temperature measurement drift with ambient temperature	0.2 ° indicated / 1 ° ambient (°C or °F)			
System Thermal Resolution* (rms value)	0.3 °C at 200 °C (rms) 0.5 °F at 392 °F (rms)		0.15 °C at 50 °C (rms) 0.27 °F at 122 °F (rms)	
Field of view (H° x V°) (Factory option)	32 x 24	16 x 12	32 x 24	16 x 12
Single Pixel FOV: (single pixel, distance: target ratio)	570:1	1140:1	570:1	1140:1
Focussing Range	0.5 m / 19 in to infinity	1 m / 39 in to infinity	0.5 m / 19 in to infinity	1 m / 39 in to infinity
Frame Rate	7.5 / 30 Hz			
Image Pixels	384 x 288			
Detector	uncooled amorphous silicon focal plane array			
Ambient Temperature Range	5 to 50 °C / 41 to 122 °F			
Dimensions (w x h x d)	258 x 305 x 330 mm / 10 x 12 x 13 in (including protective enclosure)			
Weight	4.5 Kg / 10 lb (20 kg / 44 lb including protective enclosure)			
Sealing	IP65			
Vibration	0.5mm, 10-60Hz; 3g, 60-300Hz			
CE Certification	EN 61326: 1999 A			

All accuracy specifications:

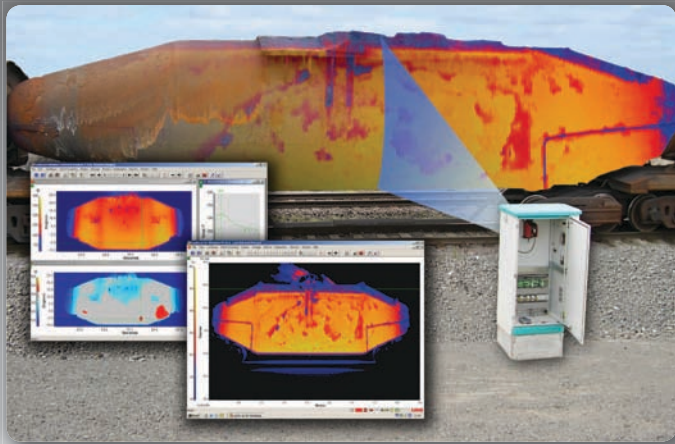
a) are stated for 30 °C / 86 °F indicated ambient temperature

b) % specifications are "% of reading" and apply to measurements in both °C and °F

* (Average of 5x5 pixel area over 25 frames)

Sensor Supply Unit	
Functions	Local connection interface between imaging sensor and image processing system
Protective Enclosure	
Service	Water, air, power input, communications, video, located to the rear of the enclosure
Air Bleed	Provides positive pressure within the enclosure
Environmental Rating	IP65

Other Process Imaging Application in the Steel Industry



The **LAND Torpedocar Temperature Profiling System** uses a Landscan Infrared Linescanner to produce highly detailed thermal profiles of each side of the torpedocar. The close measurement distance enables the system to view very small surface details, easily identifying the development of hotspots



When liquid steel is tapped from a basic oxygen or electric arc furnace, it is essential to minimise the quantity of slag carried over into the ladle.

The **LAND Slag Detection System** is an integrated solution meeting the temperature measurement requirements of steel plants across the world, enabling accurate control of slag carry-over.

Intelligent Imaging

Intelligent Imaging solutions aim to solve problems by providing more than just a measurement. Land is able to provide a custom solution according to your requirements; this includes custom temperature ranges, application specific mountings, and bespoke communications protocols.

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Non-Contact Temperature Measurement Solutions

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MANAGEMENT SYSTEM