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1. Introduction

The Logika Technologies Furnace Camera System (FCS) is designed for use in steel, aluminum and other metal mill production lines, allowing operators to observe materials in furnaces. It can also be used to monitor combustion in power and boiler operations. It includes a rugged enclosure protecting a high resolution camera that will withstand the harsh ambient conditions present in heavy industrial environments.

The Camera System includes water cooling and air purge to enable the camera to work in the hostile environments around industrial furnaces. Temperature sensors and an Automatic Retraction System provide insurance against overheating. Localized electrical and pneumatic panels simplify installation.

Applications include:

- Steel – Blast, Melt and Reheat Furnaces
- Cement – Clinker Cooler, Rotary Kiln
- Power Generation – Combustion Monitoring
- Glass – Float Glass Line
- Waste Combustion – Grate Firing
- Clay and Ceramics – Kiln Monitoring

2 Specifications and Performance

2.1 Specifications

| Operating Temp | Temperature inside the furnace ≤ 2000°C  
Auto-exit device ≤ 90°C, control system ≤ 70°C |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Supply</td>
<td>Compressed air, inlet pipe diameter G ½”, pipeline diameter G ¾”</td>
</tr>
<tr>
<td>Power Input</td>
<td>110VAC 60Hz, 220V 50 Hz, &lt; 120W</td>
</tr>
<tr>
<td>Output</td>
<td>Hi resolution NTSC color composite signal</td>
</tr>
</tbody>
</table>
| Compressed Air | Pressure 0.1-0.7 MPa (15 to 100 psi) dependent on temp inside furnace  
Flow: 0.1-0.4 m³/min (3.5 to 14 cfm)  
Inlet temperature of compressed air ≤35°C (95°F) |
| Lens           | Special high-temperature resistant pinhole lens |
| Image Index    | Resolution ≥ 650 lines (976 x 572 pixels), Signal-to-noise ≥ 42 dB  
Visual angle (diagonal line) 82° diagonal, Image Sensor 1/3”  
Signal to Noise Ratio >50 dB, sensitivity 0.1 lux |
| Auto Retract   | Auto Retract occurs at i) over-temp, ii) power loss, iii) compressed air loss |
| Weight         | Auto-exit device approx 30 kg; furnace wall cover approx 30 kg (depending on configuration) |
| Dimensions     | Auto-extract device 1280 (L) × 320 (W) × 480 (H) mm (50”L x 12.6”W x 19”H) |
| Furnace Hole   | ø 140 mm, 120° cone-like hole in interior furnace wall |
2.2 Camera Field of View

Field of View Calculation:

\[ H = \frac{h \times L}{f} \quad W = \frac{w \times L}{f} \]

Where:

- \( f \) = (focal length of pinhole lens) = 3.5 mm
- \( H \) = (height of field of view) (m)
- \( W \) = (width of field of view) (m)
- \( L \) = (the distance between the lens and target) (m)
- \( h \) = (1/3” height of camera sensor) = 3.6 mm
- \( w \) = (1/3” width of camera sensor) = 4.8 mm

<table>
<thead>
<tr>
<th>( L ) (m)</th>
<th>3.5</th>
<th>4</th>
<th>4.5</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<tr>
<td>( H ) (m)</td>
<td>3.6</td>
<td>4.1</td>
<td>4.6</td>
<td>5.1</td>
<td>6.2</td>
<td>7.2</td>
<td>8.2</td>
<td>9.3</td>
<td>10.3</td>
</tr>
<tr>
<td>( W ) (m)</td>
<td>4.8</td>
<td>5.5</td>
<td>6.2</td>
<td>6.9</td>
<td>8.2</td>
<td>9.6</td>
<td>11.0</td>
<td>12.3</td>
<td>13.7</td>
</tr>
</tbody>
</table>

2.3 Auto Retraction Assembly

Pneumatic cylinder actuated mechanism. It is designed to automatically withdraw from the furnace under the following conditions:

- Lens temperature exceeds value programmed into temperature controller (e.g. 100°C)
- Compressed air supply for cooling drops below 0.3MPa (44psi)
- Electrical power loss or interruption
2.4 Manual Control

The lens/camera assembly can be safely extended into or retracted from the furnace interior via supplied electronic control box. The supplied remote interface box (within 50 meters) also provides this function to operator. Operator will be locked out from manually inserting lens via electronic control box or remote interface if there is insufficient air, a high temperature alarm or lack of power.

2.5 Camera System

- Video output: VBS: sync Negative 1±0.21VP-P, 75Ω, BNC
- ScanMode:
  - PAL 625 Line Horizontal
  - Vertical 50Hz, Horizontal 15.625 KHz
  - Interlace Scan 2:1
- Brightness level: ≥8
- Signal to Noise Ratio: Color≥42 DB, B/W≥46 DB
- Clarity: Color≥380 line, B/W≥450 line
- Field of View: 82° (Diagonal line)
- Minimum Illumination: Color 0.8 Lux B/W 0.02 Lux

2.6 Retract Distance

- Retract distance for the camera assembly is 1000 mm

2.7 Mechanical Dimensions

- Auto retract assembly
  - 1400(L)x 200(W)x 320(H)mm
  - (55”(L) x 8”(W) x 13”(H))
- Control Box(X2)
  - 380(W)x150(D)x 450(H)mm
  - 15”(L) x 6”(D) x 18”(H)
- Remote interface
  - 430(L)x 190(D)x44(H)mm
  - 17”(L) x 7.5”(D) x 1.7”(H)

2.8 Operating Temperature(s)

- Furnace interior ≤2000 °C
- Auto-Retract Device -5~100°C
- Remote Control device -5~70 °C
- Recommended Cooling Air:
  - Compressed Instrument Air – free of water or oil
  - Oil/water separator provided as precaution
  - Nitrogen may be used as alternative
  - Pipe line connector: G ¾” outside thread
  - Supplied air pressure: 0.3~0.7 Mpa
  - Supplied air flow: 0.1~0.3 m³/min
  - Air temperature at inlet to camera system: ≤35°C
• Purge Air:
  Plant Supplied Compressed Air
  Pipe line connector: G \( \frac{3}{8} \)" outside thread
  Supplied Air pressure: 0.1~0.2 Mpa
  Supplied Air flow: 0.05 ~0.1 m\(^3\)min
  Air temperature at inlet: \( \leq 40^\circ \)C

• Power requirements
  85VAC--260VAC/50-60Hz
  Power consumption \( \leq 30\) W

3 Introduction to System Operation

The system consists of the following components:

• Electronic and Pneumatic Control box
• Remote interface (not depicted)
• Monitor (not depicted)
• Camera Assembly (including high temperature pinhole lens)
• Auto Retraction assembly (pneumatic)
• Air/water Cooling system
• Oil/water separation tank

Basic System Illustration:
3.1 Video System

Video system consists of CCD Video Camera, pin-hole camera lens and monitor. The lens is installed inside a high temperature tube which extends into the furnace. The video output signal is connected to electronic control box, then sent to the monitor in the control room.

Camera automatically selects:
- Color Video output when: CCD target illumination >0.8 Lux
- Black and White output when: CCD target illumination ≤0.8 Lux

Generally these illumination conditions are found when:
- Target area temperature >800°C -- Color camera output
- Target area temperature ≤800°C -- Black and White camera output

3.2 Cooling System

Cooling system consists of air cooling, air purging and water cooling.

Reference drawings:
- Appendix Fig. 1 Pneumatic FCS installation drawing
- Appendix Fig. 2 Pneumatic control box Flow chart

Air Cooling function and pipe routing
- Function: remove heat from inside the camera assembly
- Routing inside pneumatic box: Air in $\rightarrow$ RV1 $\rightarrow$ RV2 $\rightarrow$ Air Cooling (see Figure 2)
  Pressure Switch RV1 default value is 0.35MPa.

Purge Air function and routing
- Function: Maintain an unobstructed view of the target.
  Protect the camera lens from debris, scale and flame, while cooling the outer lens cover and refractory tube.
  Prevent high temperature from heating the camera system
- Routing: Air Purging $\rightarrow$ S2 $\rightarrow$ G ½” (underneath furnace refractory sleeve) $\rightarrow$ High Temperature Lens Tube

There is no special requirement for purge air. Air pressure and flow should be strong enough to blow the flame away from lens tube.

Water cooling function and routing
- Two G½” fittings are installed on the side of furnace refractory sleeve for inlet and outlet of water cooling system. The lower fitting is inlet and higher fitting is outlet. It is designed to prevent the high temperature in furnace shell from heating auto retract assembly directly. No special need for water.
3.3 Electronic Control System

The two main components are the electronic control box and remote interface.

- Electronic control box
  
  Button: Extend (Green): insert camera lens assembly into Furnace
  
  Retract (Red): withdraw camera lens assembly from Furnace
  
  Power indicator: DC +24V on
  
  High Temp indicator: Lens Temperature exceeds set value
  
  Low Press Indicator: Air pressure below set value
  
  UPS Power (Optional): When no AC input, system is powered by UPS

  Temperature display unit uses PT-100 RTD as the input sensor, which is installed near the camera lens tip inside the high temperature cover. It is used to monitor the temperature of camera lens assembly. The PLC will generate extend and retract signals when both temperature and air pressure are within settings (Temp below alarm setting, air pressure above alarm setting). If either is condition is not met, lens assembly retracts from furnace and the panel alarm indicator will turn on.

  UPS (Uninterrupted Power Supply) is optional. With no UPS; the pneumatic control system will retract when system loses power. When UPS is connected, the UPS indicator light will remain on, but lens won't automatically retract when system loses power.

- Remote Interface

  Remote interface is located in control room and connected to the electronic control box with a cable. It extends the function of all buttons and indicators to the control room.

3.4 Auto Retract Assembly

The main component of the auto retract assembly is the pneumatic cylinder. A solenoid (direction control valve) inside pneumatic control box controls the air direction to extend or withdraw the piston rod of cylinder. The piston rod is connected directly with the lens and camera assembly. This motion brings the camera lens in and out of the furnace.

4 System Installation

In order to improve the stability, reliability and durability of the system, it is important to select an ideal compressed air source, select the ideal location for the system and follow the installation procedures.

4.1 Auto Retract Assembly Installation

Following the mechanical dimensions (Fig. 1) of the furnace refractory sleeve, bore the appropriate hole into the furnace wall. Weld the mounting brackets onto the furnace wall. Bracket Specifications: max 1000 kg impact. If furnace wall is not strong enough, reinforcement for this area is required). Alternatively, for a 0° to +/-5° angle installation to
furnace wall, 2"x 2" or 3"x 3" angle iron can be used in place of supplied mounting brackets by MIG, TIG or ARC welding and drilling 4 respectively spaced holes to receive the pre-threaded mounting holes of the water cooled plate.

Use the 4 provided nuts and washers to fasten the refractory sleeve and water cooling plate together. Apply no more than 12ft.lbs (16N.m) torque and apply high temp thread locker. Insert this assembly into the bored hole in the furnace wall, using the nuts and bolts to mount it to the welded brackets on the furnace wall. Use refractory cement or high temperature batting to seal any gaps.

Mount the Auto Retract Assembly to water cooling plate assembly with the 6 M12 nuts.

Torque Sequence: top-right, bottom-left, middle-right, middle-left, top-left, bottom-right

Torque down Bolts in 2 Stages – First stage 15 ft/lbs (20Nm), Second stage 25 ft/lbs (34 Nm)

Pneumatic and Electronic control boxes are supplied with 2 support brackets. The recommended distance between auto retract device and control system should be within several meters. If the ambient environment is not good for installation, increase the distance. Use conduit to connect to the auto retract device (total distance must be less than 50 meters).

4.2 Cooling Air and Water Line Installation

See the Pneumatic FCS Installation drawing (Fig.1) for reference.

- **Cooling air pipeline**
  Compressed air source-air filter: G½" 1.5m steel braided hose (10)
  Air filter-Pneumatic control box: G½" 1.5m steel braided hose (9)
  Pneumatic control box-Auto Retract Assembly: G¼" 4m steel braided hose (11)
  Auto Retract Assembly—Camera Assembly: G¼” 1.5m steel braided hose (12)

- **Purge air line**
  Using G½” rigid pipe, connect air source to purge inlet on embedded assembly. (or use G½” 1.5m steel braided hose)

- **Pneumatic cylinder air lines**
  Connect extend and retract outlets in pneumatic control box to air cylinder in auto retract assembly with 2 G¼” 4m steel braided hoses (11x2)

- **Water cooling pipeline**
  If environment temperature is high (exterior furnace wall ambient temperature is greater than 90°C), water cooling system should be utilized. Shutoff valves should be installed on the inlet pipe line. The lower connector on the water cooling plate is the inlet line and upper connector is the outlet line.

4.3 Electronic Control System Connection

Follow Fig.3 Electronic connection drawing and Fig.1 Pneumatic FCS installation drawings. Exposed wires outside the control box should be run through conduit for protection.

Due to the distance between camera and monitor, SYVPVP75-5 video cable is selected to improve the video picture quality. If the ambient temperature is greater than 65°C, use high temperature cable.
4.4 Pipeline Installation

Customer should complete the pipe lines within the dashed region of FCS Installation drawing. also support all the parts for installation changes. The metal pipes and connectors should be cleaned and ensure no burrs.

The compressed air lines should be angled for the condensed water to drain out. A drain valve should also be installed in the air line. If the air lines pass through a high temperature area of the plant, re-route or insulate the lines to ensure inlet air temperatures for the FCS pneumatics control box are maintained at <35°C.

Using G¾” pipe, install the compressed air lines and add a shut-off valve approximately 0.5M from control box. Also install a G½” outside thread connector to the open side.

Using G¾” pipe, install the cooling air lines and add a shut-off valve approximately 0.5M from embedded assembly. Also install a G½” outside thread connector to the open side.

All the pipe/lines should be subjected to a pressure/leak test before use.

Before connecting to the FCS, the cooling air lines should be purged to atmosphere in order to remove any condensation and residue.

5 Final Inspection and Testing

5.1 Before Firing Up Furnace

- Follow the installation drawings, and visually check the Lens assembly, auto retraction assembly, pneumatic control box for correct installation.
- Follow the electronic schematic and check the electronic control box
- Confirm that grounding wire is connected
- Connect the remote interface.
- Turn power on.
- Check the power indicators on electronic control box and remote interface. Low pressure indicator is displayed with panel light marked “PreL”
- Slowly open the compressed air valve, set the pressure limit switch to 0.35MPa, and adjust the pressure reducing valve (AW40-04D).
- Adjust the inlet air pressure to 0.4Mpa; the pressure warning indicator should now turn off. Adjust second pressure reducing valve AR40 in the air cooling line to 0.25Mpa; cooling air should now come out of the camera assembly.
- Press the Extend and Retract Buttons on electronic control box or remote interface, the lens assembly will act accordingly. When lens temperature or pressure requirements are not met while the lens assembly is retracted, the manual functions on remote interface and electronic control box will be locked out until the temperature and pressure has returned to normal operating levels and panel warning lights turn off.
- Auto retract assembly test

In the following conditions, the retract assembly will activate and withdraw the lens:

1. Shutting down or decreasing pressure reducing valve or dropping the inlet compressed air pressure to less than 0.35MPa.
② Drop the temperature setup limit value on temperature controller to a lower value than the actual displayed temperature.
③ If equipped with UPS, AC input power loss only turns the yellow indicator on but does not activate the retraction assembly.

5.2 System Operation in High Temperature Furnace
Attention: Ensure that the cooling air is connected to camera assembly and in normal working condition before extending the camera system into furnace.

Test the video image when the furnace is operating at its highest temperature. Based to the illumination level inside the furnace, adjust the camera’s aperture and lens filter to obtain the best quality of picture on the monitor screen. Refer to the supplied video camera user’s manual for adjustment and operation.

6 System Maintenance
System maintenance should be performed by trained staff. For video camera and monitor maintenance please refer to the supplied manuals.

6.1 Control System Function Test
The Control System should be tested regularly to ensure the system is in good running condition. Follow 5.1 Auto retract assembly test procedure to check the button operation and system function.

6.2 Mechanical Inspection
All mechanical connections should be cleaned periodically and moving parts lubricated with a high temp non flammable lubricant. Remove the side cover on the auto retraction assembly; ensure that mechanical/fastener connections are hand tight, and inspect rail and cylinder for signs of wear or damage. Also inspect for any noticeable air leaks in the air lines.

6.3 Maintenance of the Lens
Dust on lens will cause a blurred picture. Under these conditions, the lens needs to be cleaned. Retract the camera lens assembly from furnace, and shut down the inlet air. Gently clean the lens with lens paper. It is not necessary to remove the camera and lens from the assembly. There are no plant serviceable parts in the high temperature pin hole lens assembly, please contact Logika Technologies for service of these parts.

6.4 Compressed Air System Maintenance
Check pipe, fittings and hoses and connectors for leaks or poor seals. Periodically replace all air filters as required.
Note
RV1 (left to right)
Filter with auto drain
Pressure reducing valve
Air pressure gauge
Adjustable pressure switch
Micro mist separator

KV1 Check Valve
XS1, XS2 Muffler
Y1 Solenoid (Direction Control Valve)
LBI Air Accumulator
RV2 Pressure Reducing Valve
DV1, DV2 One Way flow control Valve, adjustable

Fig. 2
Pneumatic Control Box
Flow Chart

Logika Technologies Inc.