

HUMOS MONITORING SYSTEM OF LEAKS IN TO THE CONTAINMENT ATMOSPHERE

O.MATAL, J.ŽALOUDEK, O.MATAL jun, J.KLINGA

Energovýzkum, Brno

J.BROM

ČEZ-NPP Temelín

1. INTRODUCTION

Humidity Monitoring System (HUMOS) has been developed and designed to detect the presence of leak in selected primary circuit high energy pipelines and components that are evaluated from the point of view of Leak Before Break (LBB) requirements, Ref [1].

Ref [2] requires to apply technical tools for detection and identification of coolant leaks from primary circuit and components of PWRs reactors. Safety significance of leaks depends on:

- leak source (location)
- leak rate, and
- leak duration.

Therefore to detect and monitor coolant leaks in to the containment atmosphere during reactor operation is one of important safety measures.

As potential leak sources flange connection in the upper head region of VVER reactors can be considered, Ref [3].

HUMOS does not rely on the release of radioactivity to detect leaks but rather the relies on detection of moisture in the air resulting from a primary boundary leak. Because HUMOS relies on moisture and temperature detection, leaks can be detected without requiring the reactor to be critical. Therefore leaks can be detected during integrity pressure tests and any other mode of operation provided the reactor ventilation system is operating and primary circuit and components are pressurized.

2. FUNCTIONAL REQUIREMENTS

HUMOS shall be capable of:

- detecting leak rates from high energy pipelines and components of 4 liter per minute within one hour,
- detecting required changes in air humidity,
- detecting required changes in air temperature,
- leak rate estimation.

HUMOS also meets following functional requirements:

- on-line (automatic) operation,
- off-line operation (dialog with operator)
- to provide alarms and diagnostic messages,
- electromagnetic compatibility (to meet requirements of IEC801-2, IEC801-3, IEC801-4 and IEEE C62.41),
- environmental requirements and radiation resistance
- self testing during operation
- quality assurance.

3. HUMOS DESIGN

3.1. Hardware Design

A schematic diagram of the HUMOS hardware is in Fig. 1. Hardware consists of:

- integrated humidity and temperature sensors
- cables (sensors - DAQ units)
- DAQ units
- communication and power cables (DAQ units - containment penetrations - cabinet)
- cabinet with an industrial PC and accessories (power supply units, power distribution etc.)

Cabinet is located in the diagnostic room.

3.2. Software

The HUMOS version for NPP Temelín runs under operating system MS DOS 6.0 or higher. HUMOS software design meets requirements listed bellow, namely:

3.2.1. User Environment is:

- Using the mouse
- Graphics environment that fully supports keyboard and/or mouse control
- Menu choice
- Windows (program user communication takes place in user windows)
- Text windows
- Graphics windows
- Information windows
- Messages windows

3.2.2. Screen Layout

The screen is divided into five region from top to bottom:

- Application name,
- information area,
- main working area,
- messages area, and
- main menu.

3.2.3. Menu (Mode)

Alone quick change mode:

- Entering passwords
- Mode change - on-line, off-line, stand-alone.

3.2.4. Menu System

In this window user can set some system variables, such as a working mode or passwords, perform system tests, obtain information about program and system or quit to operating system.

- Entering passwords.
- Window system (Mode, Computer Test, Measuring System Test, Communication Test, General Test, System information, Program information, External Tests, Quit).

3.2.5. Menu Diagnostic

Shows the current system diagnostic, list of all active alarms in given moment.

3.2.6. Menu Display

User can select a format for data display. Data are displayed direct in the main working area or a separate window is opened.

- Graphics display shows the time history of selected output.
- Digital display can be used to display current values and status of all sensors.
- Sensor layout can be displayed.

3.2.7. Messages

In this window (screen area) all alarms, warnings and other messages are displayed.

3.2.8. Menu Area-Graph

In this menu all functions to control graph area are listed:

- Move.
- Zoom.
- Offset (allows to change relative position of displayed time history).
- Show (this function allows to identify any from displayed lines include display of values in given point and change of lines setting).
- Normal.
- Back (previous graph is redrawn).
- Load Graph (allow to load predefined or user stored graphs).
- Save Graph (the graph will be saved under the name).
- Set Axis X.
- Set Axis Y.
- Select Showed Sensor Output.
- Lines Identification.
- Graph Set.

3.2.9. Menu Area - Digital

Following menu can be displayed:

- Update (list of digital displayed points according to newest value).
- In Color (lines with sensor in alarm state are displayed).

3.2.10. Menu Print

If a printer is connected, the output goes to this printer.

3.2.11. Menu Help

Corresponding help to action or current window can be displayed.

3.2.12. Error Messages

If system error occurs, this error is reported in an error message window. (Examples: PC/TCP resident module is not loaded, not enough memory, cannot write temporary file etc.).

3.2.13. Alarms and Diagnostic Messages

System alarms show that a phenomenon pointing to a possible hardware or software error was detected and/or leaks are detected.

3.2.14. Sensor List

3.2.15. Leak Location and Leak Estimates

4. HUMOS TESTS

4.1. Test Design and Test Apparatus

Test were performed to demonstrate that small amounts of humidity released by a leak into air stream in containment can be detected. The tests attempted to simulate the specific mass flow rates of both the air and potential leaks during normal reactor ventilation operation. In order to accomplish this test apparatus of duct, fan and injection devices were designed and built in Energov'zkum.

A schematic diagram of the test apparatus is in Fig.2. The test apparatus housed following components:

- fan powered by an asynchronous electric motor (fan volumetric rate up to 30 m³ per second),
- inlet air filter,
- exhaust pipeline section of the diameter of 1000 mm,
- water/steam into air injection unit,
- humidity, flow rates, temperature and pressure sensors,
- data acquisition and evaluation system.

4.2. Water / Steam into Air Injections (leak simulations)

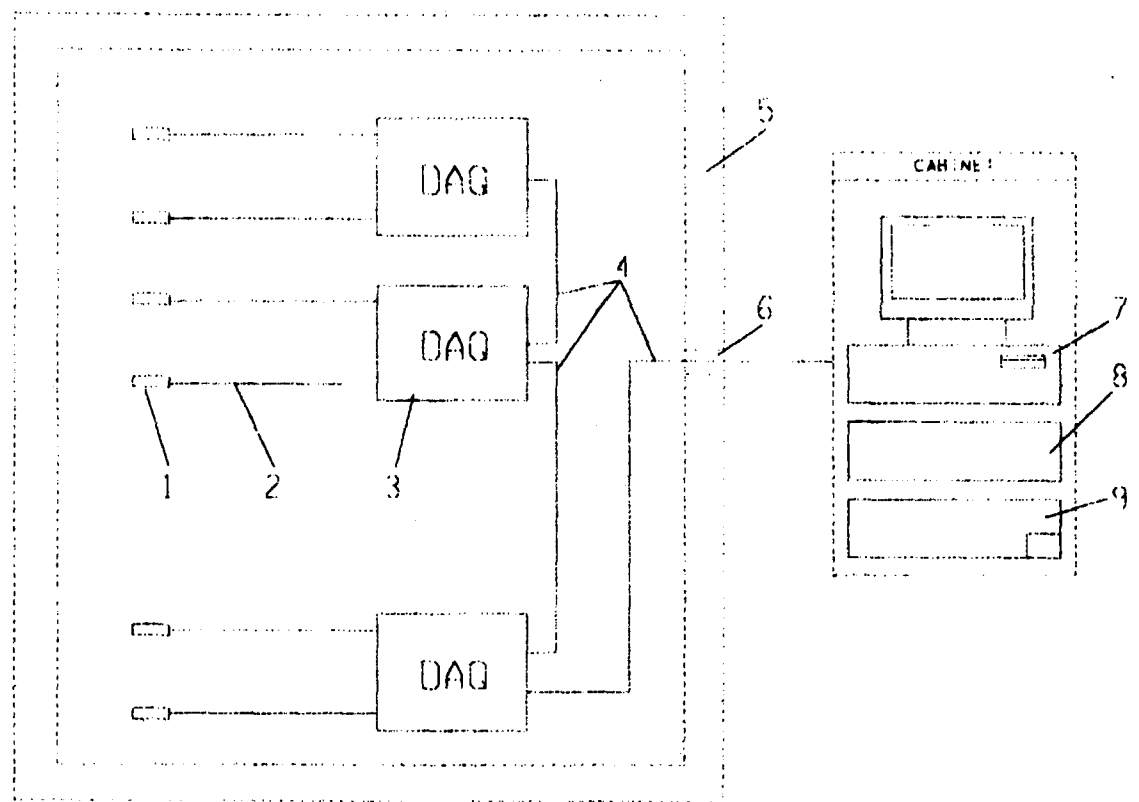
Series of water and steam injections into air were performed at the air volumetric flow rates of 2 to 10 m³/s and injected mass flow rate of 0,04 to 130 g/s (0,24 to 10 l/min) and sensors responses were measured and evaluated.

4.3. Sensor Response to Leaks

An example of sensors response on leak rates at a constant air flow rate is in Fig.3. Obtained test results correspond to theoretical predictions.

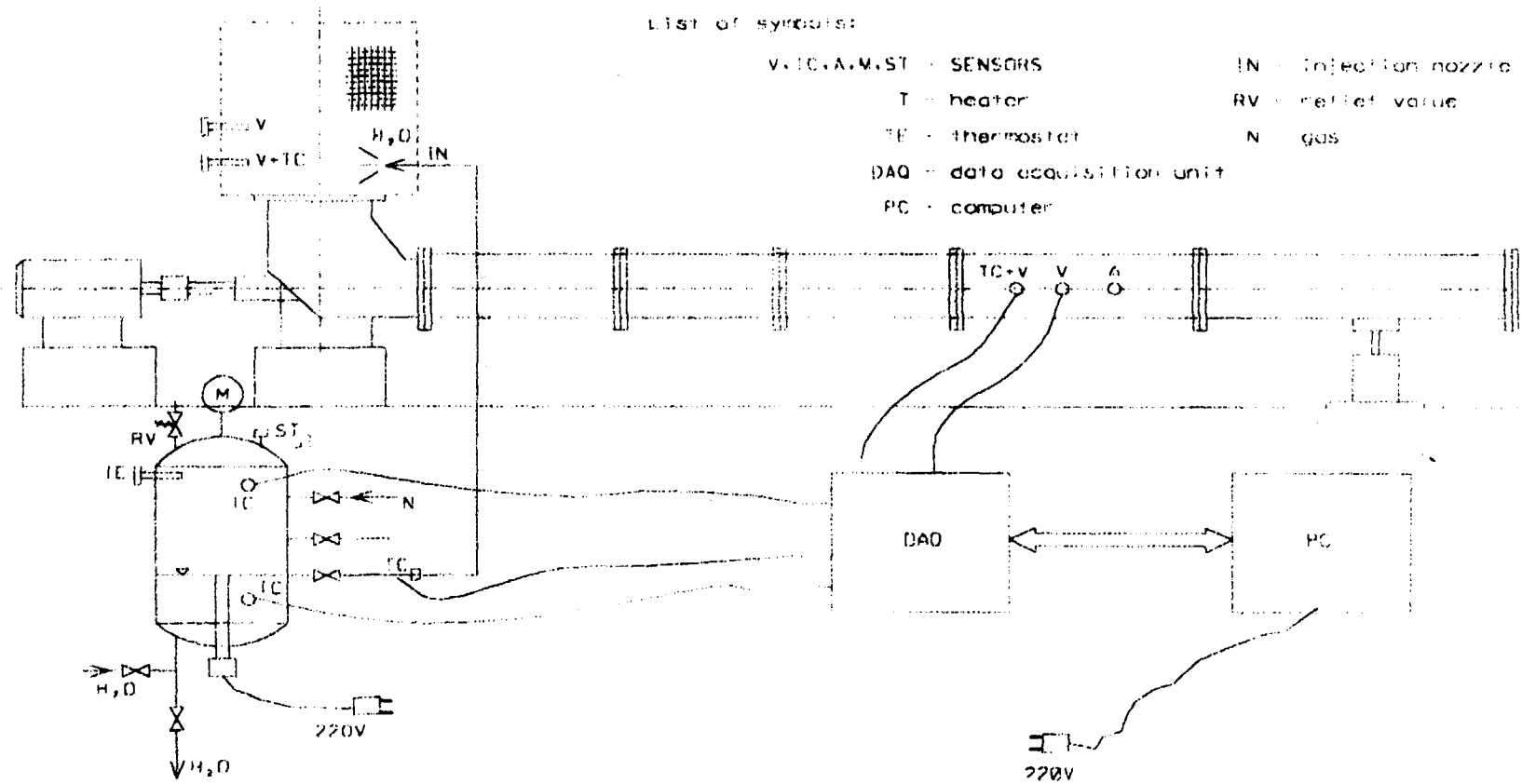
5. REFERENCES

- [1] Procedure for LBB qualification, Requirements on Safety Reports Content and Scope, ČSKAE 1/1991
- [2] U.S. Regulatory Guide 1.45, Reactor Coolant Pressure Boundary Leakage Detection Systems
- [3] Requirements Nr. 352-TZ-281, OKB Hidropress, 1987



- 1 - INTEGRATED SENSOR
- 2 - CABLE
- 3 - DAQ UNIT
- 4 - COMMUNICATION AND POWER CABLE
- 5 - CONTAINMENT PENETRATION
- 6 - CONTAINMENT
- 7 - IBM PC INDUSTRIAL COMPUTER
- 8 - POWER SUPPLY
- 9 - POWER DISTRIBUTION UNIT

Fig.1: HUMOS hardware configuration



List of symbols:

V, TC, A, M, ST - SENSORS

T - heater

TE - thermostat

DAQ - data acquisition unit

PC - computer

IN - Injection nozzle

RV - reflect valve

N - gas

Fig.2: Schematic diagram of the HUMOS test apparatus

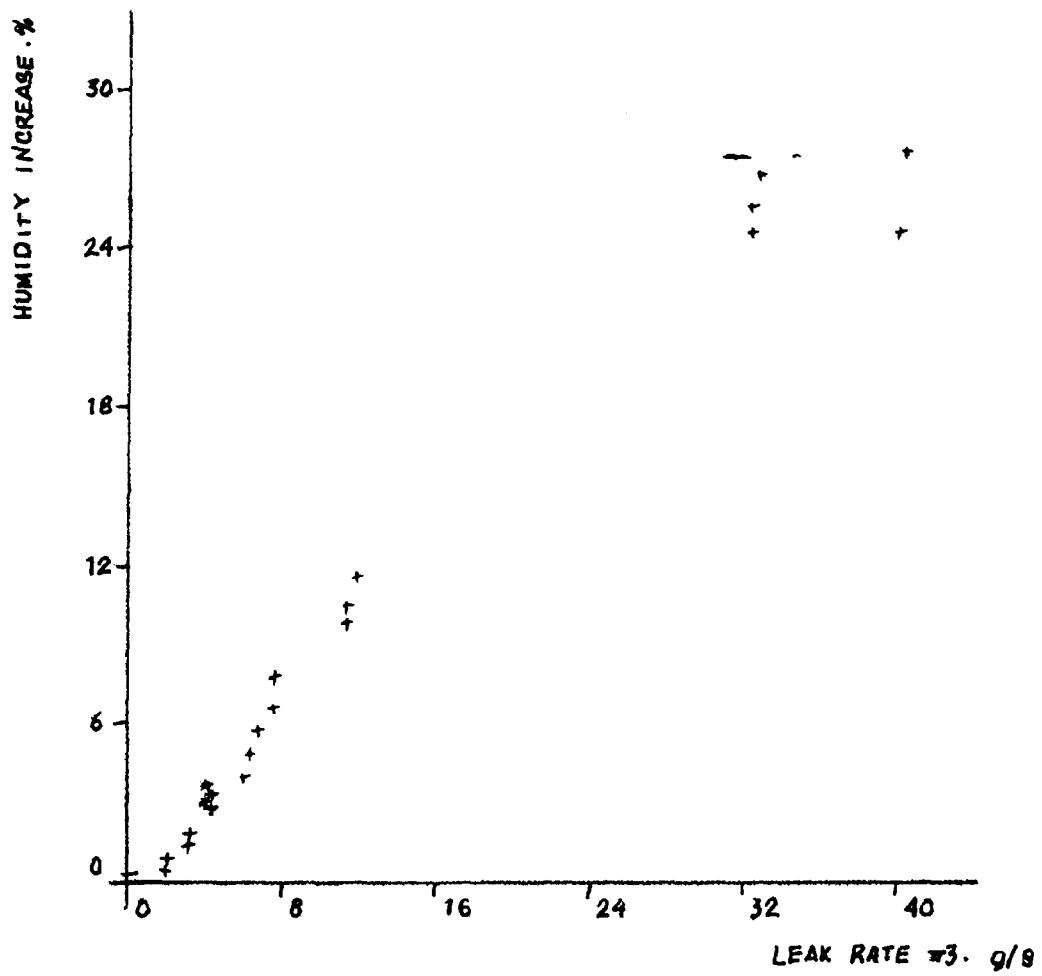


Fig.3: Humidity sensor responses on injected water (+) and steam (*) rates m_3 at a constant air flow rate