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TITLE

Laser Surveillance system (LASSY)

FINAL REPORT FOR THE PERIOD

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LASER SURVEILLANCE SYSTEM (LASSY)

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Final Report for Research Contract 4273/R4/RB

1. Overview

This final report on the Laser Surveillance Program for surveillance of spent fuel elements (LASSY) gives an overview of the LASSY development since 1983 under IAEA contract 3458/RB and summarizes the results of the final contract year (4279/RB) ending by March 3rd, 1991.

2. LASSY development since 1983

The first LASSY contract started on October 1st, 1983, with the contract no. 3458/RB. Its main activities focused on the development of a laser eye and of preliminary tests of laser light behavior under different water conditions. In spring 1984 a 20 m long plastic tube (diameter 40 cm) filled with deionized water was installed at the Atominstitut Wien and a beam of HeCd laser light emitted from the newly developed eye and reflected at the tube end was easily detected.

In June 1984 one LASSY eye was installed in the spent fuel pool of the CCR Ispra and tested successfully. At that stage it was decided to extend the LASSY system to two rotating laser eyes and perform a test in a fairly large non-nuclear pool.

In March 1985 an appropriate non-nuclear pool was found in a hall next to the VIC belonging to the Technical University of Wien. This pool was normally used for water flow tests of the Institute of Hydroengineering of the TU Wien. It consisted of a shallow (~ 50 cm) rectangular pool with the dimension of 10 m x 15 m. This pool was filled with destilled water and the two laser eyes were tested successfully including the control program unit. The final progress report on IAEA contract no. 3458/RB was submitted to the IAEA in April 1985 /1/ and covers the results of the experiments at the Atominstitut and in the non-nuclear pool.

As a follow-up contract the IAEA contract 4279/RB was started on April 1st, 1985, which culminated in a three week field test of the LASSY system in block 2 of the Paks Nuclear Power Plant in Hungary. The evaluation and results of this field test are summarized in a progress report to the IAEA in April 1986 /2/.

Immediately after this field test, it was decided to construct an engineered prototype laser system and the project was shifted from Wien to Ispra in cooperation with the Atominstitute. Main improvements are better focused laser eyes, new electronics and improved computer programs. This work was performed during the period June 1987 to the end of September 1989 and respective progress reports were submitted to the IAEA /3,4/.

To test this engineered prototype a field test was carried out in the FIAT plant C.I.E.I. at Saluggia/Italy which started in October 1989. This test was carried out with one laser eye in air. The results of this field test are highlighted below.

3. Final results on LASSY tests in FIAT, Saluggia/Italy

The field tests of LASSY have been carried out in the plant of FIAT C.I.E.I., storage Avogadro at Saluggia in Italy. I want to acknowledge the excellent collaboration of Mr.Graziani and his staff during the whole test period. Their assistance during installation and the monitoring of the equipment afterwards have contributed considerably to the positive results of the field tests. At Saluggia the laser system has been operated in air. Another report deals with the tests of LASSY underwater at JRC facility.

Installation

The first LASSY prototype realized at JRC Ispra was installed in October 1989 in the storage Avogadro in a stand-alone version, that means without connection to a video surveillance system. The configuration comprised one eye operating in air about one meter above the storage pool just above the pool surrounding wall (see attached figure of LASSY installation in appendix 1).

The distance between the laser eye and the background walls varies from 29 to 12 meters over the 90 degrees of scanning. The whole equipment including the measurement electronics, the laser part, the motor control and the computer which are powered by a battery backup to assure the correct operation in case of main failure up to two hours. A short over-

view of the technical specifications are given in the appendix 2. A laser diode of 2 mW has been used for the tests.

In a second phase (June 1990) a video surveillance system was added comprising a TV camera and a time lapse recorder. Since the illumination level is rather low when the operator switches off the main lights, a Newvicon camera from Magneti Marelli was chosen. The time lapse recorder is a GYYR model TLC 2051. The LASSY computer outputs a trigger signal to the recorder for each detected alarm.
In addition the video recorder records pictures at fixed time intervals.
- Recording mode: continous in time-lapse, speed P1=999 h.
- Alarm recording: duration controlled by computer.
The computer is a PC Compag, model 386/20e with a 40 MB hard disk and a printer.

Parameter setting

A certain number of parameters can be selected by software to adjust the system performance to the installation site. Once selected, these parameters are recorded on disk and are used by the automatic surveillance program. The main parameters are:

- resolution (number of scanning points over 90 degrees)
- scan time
- combination of consecutive scanning points for alarm.

A list of the system parameters with the selected values for Saluggia is given in appendix 3. The choice of the parameters depends on the object size one wants to detect, the speed of a moving object, the distance between object and laser eye, etc.

LASSY output

During the automatic surveillance the computer displays continously on the monitor the scan number, the angle position of the eye, the accepted alarm and the executed software task. If the system detects an alarm according to the set of programmed parameters, the computer triggers the video

recorder and writes a message on the disk which can be printed later on. The duration of the trigger pulse depends on the duration of the alarm but lasts at least one minute.

The recorded information on disk includes:

- date and time
- start and stop angle of the detected alarm
- the number of deviated points indicating the size of the disturbance
- the mode which indicates if the signal amplitude or the distance measurement has caused the alarm.

An example of the recorded information during the test is given in appendix 4.

Failures and corrections

There were mainly two types of failure in the first test period: one in the mechanics for the movement of the eye and the other in the software.

a) The movement of the laser eye is provided by two small motors coupled to a gear reduction unit. Several times the eye stopped and the mechanical part was blocked. We noticed an abnormal wear and tear of the gear reduction units. This was due to the fact that a rubber gasket (O-ring), foreseen for underwater operation, hardened during a longer period of scanning in air. Since the gasket is not required for air operation, we discarded it in September 1990. This has solved the problem of mechanical failures.

b) The second type of failure was due to a bug occurring in the execution of the automatic surveillance program. The software has been modified by the following actions:
   - simplifying the structure originally designed for two eyes
   - eliminating the internal timers and the background job
   - substituting the assembler driver of the input/output board by a standard driver in c language.

   After these modifications carried out between July and October 1990, the application software worked in a reliable way.

c) One occasional failure in August 1990 was due to the faulty operation of the printer which caused the stop of the surveillance program. The alarm messages originally directed to the disk and the printer are now directed only to the disk and are printed on user's request. If required in the future, data could be written on hard and floppy disk to avoid data loss in case of failure on one unit.

An automatic restart procedure of the surveillance program has been added to the system. No failure occurred in the electronic or optical part of LASSY.

Data review

The verification of the alarm table recorded on the LASSY computer disk can be done reviewing the pictures recorded on the video tape in the same time period. Reviewing the video tapes, it is possible to distinguish the pictures recorded in alarm mode (due to the trigger of LASSY) from the pictures recorded in continuous time-lapse mode since the recording speed is different in the two modes (2h/999h). Further information on the alarm events is included in the disk files as described in chapter 4. The TV camera was located on the opposite side of the pool referring to the laser eye, so the laser system is visible on the left corner of the recorded video pictures.
The average value of alarms per month was 21; the recorded picture sequence on video tape varied between 1 and 9 minutes depending on the type of movement in the scanning area. Successive alarms in a short time interval have been recorded on tape in one sequence since the minimal duration of alarm recording is one minute. Of the total number of detected alarms 10% were nuisance alarms, 12% caused by the crane operating in the pool and 78% caused by movement of persons in the scanning area. Nuisance alarms mean that there was no visible movement on the recorded video pictures; probably the selected sensitivity was too high for this application. On the other hand all movements recorded by the video surveillance system in the laser scanning area have been detected.

Most alarms have been generated by persons moving either between the laser eye and the pool wall or on the opposite side of the pool in the scanning area. If these alarms are undesired the eye has to be installed in such a

position that the movement of persons is minimal in the scanning area. The used position in the pool of Saluggia was not the most appropriate but it was not possible to install the laser eye on the wall of the pool because of the crane movement.

The sensitivity for alarms could be adjusted by setting different parameters. The setting has to be done after the installation in a plant and should not be readjusted unless the optical or electronic part is substituted in the system. In annexe to this report is a list of the selected system parameters in the storage Avogadro.

Conclusion

Fhe following conclusions can be drawn from the field tests at Saluggia:

a) The LASSY is adapted to be used in air operationn for surveillance in areas in which few movements occur in the horizontal scanning plane of the laser beam. A good example is scanning just above the water level of a storage pool. The covered distance in this field test was about 30 m.

b) The reliability of the prototype has been considerably improved during the period of the field tests. The initial bugs in mechanics and software have been corrected and no failure occurred in 1991.

c) The verification of the alarm table on the LASSY computer with the recorded video pictures showed that all alarm situations have been detected. There were 10% nuisance alarms, 12% alarms were caused by crane operations in the pool and 78% by persons moving in the scanning area. Therefore, the location of the LASSY eye has to be chosen carefully.

d) The system can be used either in a stand-alone configuration or in combination with a video surveillance system. In the first case the result is given by the alarm table stored in the computer; in the second case there are also the recorded pictures of the detected alarms. This combination represents an integrated multi-device system based on two different physical principles.

e) The information given by the laser system cannot be substituted by camera pictures since the scanning beam creates a horizontal surveillance plane. Both devices are in some extent complementary since the laser adds some information on the third dimension.

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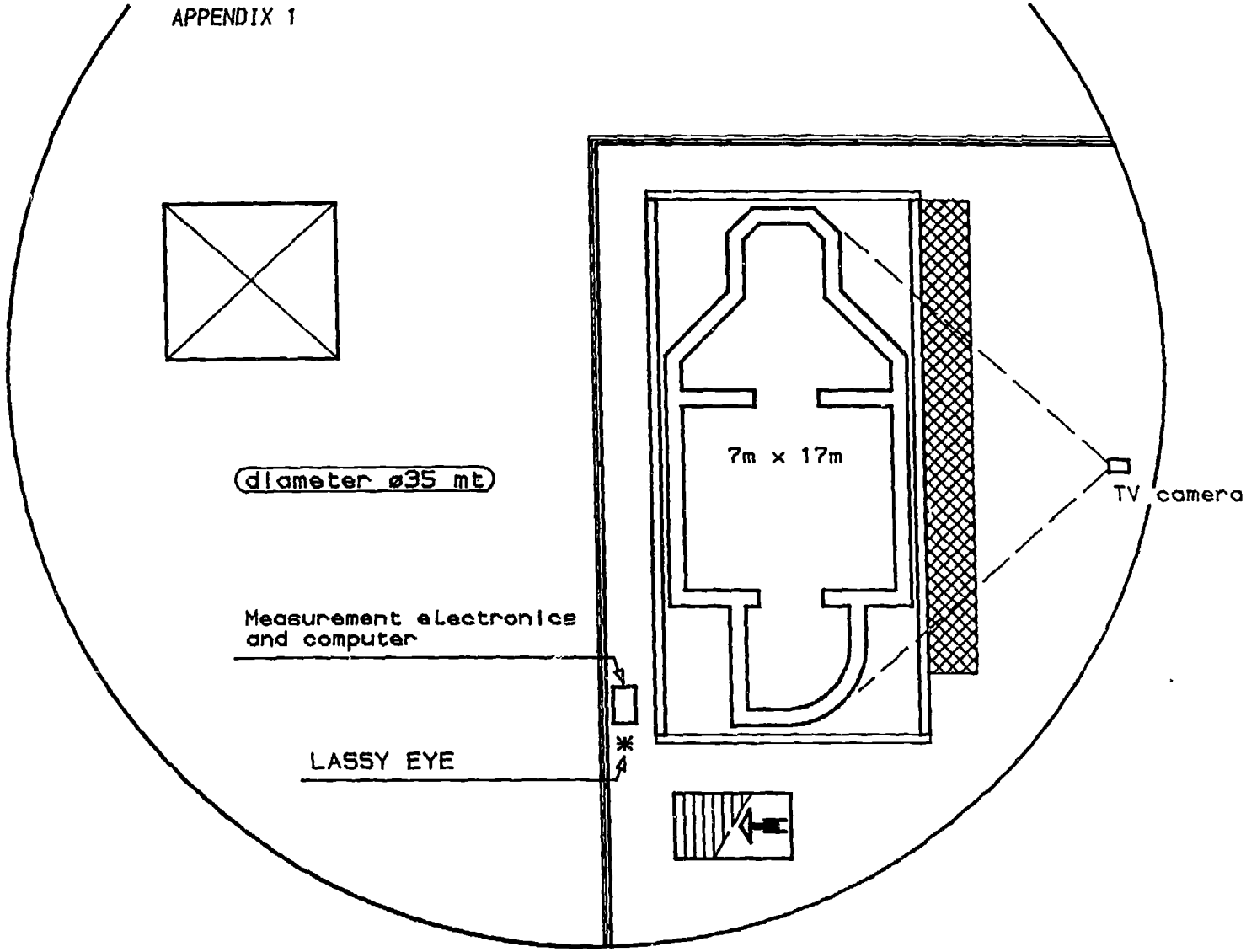
APPENDIX 1



Installation of LASSY at FIAT/CIEI/Avogadro storage pond

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APPENDIX II

LASSY TECHNICAL SPECIFICATIONS

Power requirements :	500 W
Space requirements :	one standard rack or one table for computer and electronics plus 60 cm x 60 cm for the eye
Operating Medium :	air
Operating range :	up to 30 meters using a LED (100 microW) up to 60 meters using a LD (2 mW)
Safety Class :	1 with LED 3b with LD
Scanning Angle :	programmable
Points per scan :	programmable 256, 512, 1024
Scanning time :	forward + acquisition 30 sec. for 90° with 512 points
Detection Capability :	depending on distance and background, under most conditions : objects with diameter > 15 cm

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APPENDIX III

LASSY ver. 2.0 Plant : FIAT/Saluggia

SYSTEM PARAMETERS

GENERIC

Number of records per scan per eye	[256 to 2048]	512
Overall time per scan (forward)	[5 to 900"]	30.482
Input card amplifier setting for eye 1	[1,10,100,500]	1
Output filtering	[O to 100 ms]	0
Strength of coupling between amplitude and distance	[0 to 1]	0.000
Strength of coupling to previous deviation	[0 to 1]	0.000

FOR AMPLITUDE EYE 1

Minimum deviation to establish an alarm	[2% to 20%]	20.000
Resolution (consult neighbors)	[0 to 1]	1.000
Minimum No. of alarms to establish a response	[1 to 200]	10
Minimum No. of consec. alarms to establish a response	[1 to 9]	2
Minimum No. of no-alarms between responses	[1 to 200]	20
Minimum density of alarms within a response	[0 to 1]	0.700

FOR DISTANCE EYE 1

Minimum deviation to establish an alarm	[2% to 20%]	20.000
Resolution (consult neighbors)	[0 to 1]	1.000
Minimum No. of alarms to establish a response	[1 to 200]	10
Minimum No. of consec. alarms to establish a response	[1 to 9]	2
Minimum No. of no-alarms between responses	[1 to 200]	20
Minimum density of alarms within a response	[O to 1]	0.700
Acceleration / vout to motors	[0 to 1]	0.174
Conversion offset for phase - distance	[-100 to 100]	7.000

Appendix 4

DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
LASSY ver. 2.0 Plant : FIAT/ Saluggia
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

S U R V E I L L A N C E   S T A R T E D

17/ 1/91 // 12: 2:36

item	scan no.:	date:	time:	start/stop angle	size	mode
* 1	168	1./ 1/91	14:59:47	53.09 .. 56.25 :	16	signal
* 2				53.09 .. 55.90 :	14	dist.
* 3	5109	21/ 1/91	8:39:49	78.05 .. 81.21 :	15	signal
* 4				78.05 .. 81.56 :	18	dist.
* 5	5112	21/ 1/91	8:43: 7	75.23 .. 77.70 :	13	dist.
* 6	5123	21/ 1/91	8:55:13	41.84 .. 44.30 :	11	signal
* 7	5157	21/ 1/91	9:32:32	0.35 .. 7.73 :	34	dist.
* 8	6402	22/ 1/91	8:10:28	0.70 .. 2.81 :	12	signal
* 9	6405	22/ 1/91	8 13:47	0.70 .. 3.52 :	13	signal
* 10	6554	22/ 1/91	10:57: 2	0.70 .. 23.91 :	94	signal
* 11	7781	23/ 1/91	9: 8:10	59.06 .. 61.17 :	13	signal
* 12				59.06 .. 61.52 :	15	dist.
* 13	7783	23/ 1/91	9:10:23	42.89 .. 45.00 :	11	dist.
* 14	7787	23/ 1/91	9:14:49	70.31 .. 73.13 :	14	signal
* 15	9128	24/ 1/91	8:59:34	83.67 .. 89.30 :	27	signal
* 16	12857	27/ 1/91	2:49:18	52.73 .. 89.30 :	191	signal
* 17				52.73 .. 88.95 :	189	dist.

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