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ASSESSMENT OF NUCLEAR OPERATIONS AT THE LAGUNA VERDE NUCLEAR POWER PLANT, MEXICO

CLIENT: GREENPEACE INTERNATIONAL

REPORT REF NO R3039-A1

15 MAY 2007

First Issued 3 April 2000

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NUCLEAR SAFETY AT LAGUNA VERDE

WANO FIELD REPORTS AND PEER REVIEW

The duplex BWR reactors at Laguna Verde, Veracruz[1] have been subject to a WANO Peer Review.[2]

The review mechanism involved a team of inspectors visiting the power plant and compiling a series of field and observation reports.[3] What has been made available is a compilation of the confidential WANO inspectors' reports which are unlikely to be included in the final version of the peer review but, that said, these reports provide an invaluable insight into operations at Laguna Verde NPP.

This assessment comprised two parts:

PART I SUMMARY OF ASSESSMENT

INSTITUTIONAL FAILURE

The WANO field reports identify a number of managerial and organisational areas that are weak and/or neglected at Laguna Verde, so much so that this NPP, its organisation structures and corporate management might be considered to be at the edge of *institutional failure*.[4]

Institutional failure is that where related causative factors and events combine and act in such a way as to bring the system overall down. The elements of institutional failure are not so straightforward to be categorised in a classical fashion, such as *mechanical breakdown*, etc., being very much deeper in that each relates to or is a type of *human error* or *human behaviour* active in the corporate body.

This type of failure is not unique to nuclear plants and facilities. However, because these are acknowledged highly hazardous, the *defence-in-depth* approach (involving duplication, diversity and redundancy of equipment) means that an electro-mechanical failure should not provoke collapse of the plant safety regime.

1 Laguna Verde GE Boiling Water Reactors (BWR%) located about 200km south-east of Mexico City of 628 and 654Wme capacity, commissioned in July 1990 and April 1995,

2 World Association of Nuclear Operators (WANO) Peer Review completed to draft stage by January 2000.

3 The ~200 page WANO report passed to Large & Associates by Greenpeace International is marked *"DRAFT – WANO PEER REVIEW FIELD NOTES – PRIVATE UNEDITED WORKING COPY"* AND DATED November 1999 and it contains 63 separate field reports not all of which are reviewed here.

4 Weaver K R *A Conceptual Study of the Role of the Institution in Safety*, Proc Int Symp Quality in Nuclear Power Plant Operation, Toronto 1989

This means that accidents at nuclear facilities must involve some recognisable element of institutional failure.

THE CAUSATIVE ELEMENTS OF INSTITUTIONAL FAILURE

The underlying causative factors of institutional failure can be extracted from three past nuclear accidents each of which should not have developed to such severity if the causative affect had been electro-mechanical alone.

At Three Mile Island, for example, inadequate resources, both human and material, together with long-term lack of maintenance, lack off operator training, and deficiencies in Metropolitan Edison's own quality assurance plan,[5] all contributed to the accident. At Windscale, in 1957, there were resource deficiencies including an almost complete lack of documentation relating to the critical Wigner energy annealing operation that triggered the core fire.[6]

Windscale and TMI accidents both include a *failure to allocate adequate or appropriate resources*.

The accident at Chernobyl examples another institutional failure causative element. During the hours of build up to the accident at Chernobyl, the operatives became determined to complete a planned test even though as each hour of delay past, imposed by the regional grid controller, the reactor was rendered more unstable.[7] In this situation a *production imperative* dominated the safety rationale, it injected a sense of urgency to get the job done come what may.

There are two other distinct causative elements that relate to failure to understand the limitations of the safety regime and if, indeed, the safety regime is deteriorating to an unsafe situation.

A year before the TMI accident the similar Davis-Besse NPP experienced a loss-of-feedwater transient and although this was recognised to provide opportunity for inappropriate operator actions, the warning signal was not heeded. At TMI the same transient triggered a whole cascade of failures following the automatic isolation of the condensate treatment plant. Warning signals given by past events are very important because proper detection and understanding of these provides for future signals to be correctly interpreted and acted upon. This type of omission is *failure to acknowledge or recognise an unsatisfactory or deteriorating safety*

5 Kemeny J G *Report to the President's Commission on the Accident at Three Mile Island*, US Gov Printing Office, Washington 1979

6 Penney W *Report on the Accident at Windscale No 1 Pile on 10th October 1957*, Report to the Chair of the United Kingdom Atomic Energy Authority, October 19557

7 The so-called xenon trap – USSR State Committee on the *Accident at Chernobyl Nuclear Power Plant and its Consequences*, IAEA Post Accident Meeting August 1986

situation.

Lack of appreciation of the technical limitations of the safety regime stems from failure at senior institutional levels to define the links within the safety regime. This can result in over demand on the performance of particular technical systems and/or the resources provide to it. This is illustrated at TMI where Kemeny reported a widespread lack of expertise throughout the organisation and, similarly, at Chernobyl where senior management levels at the plant and in MinAtom expressed absolute confidence in the benign safety nature to the RBMK reactor system.

APPLYING INSTITUTIONAL FAILURE TO LAGUNA VERDE

With hindsight, these causative elements can be salvaged in the aftermath of a nuclear accident by picking through the evidence and history of events that led to the institutional failure. However, the challenge here is whether the elements of institutional failure can be identified *before* a physical breakdown of the plant occurs. That is, is the situation at Laguna Verde, as reported by the WANO inspectors, indicative of developing institutional failure or is the plant's management simply in a morass ?

If Laguna Verde's management is befuddled then this, as inefficient and confused as it seems to be, may be a relatively stable position, although the overall risk of serious accident might be higher. If Laguna Verde can be categorised as being somewhere along the path to institutional failure, then the situation might be unstable with the plant being doomed to a serious accident at some time in the future.

So it is useful to assess the WANO field reports in terms of the causative elements of institutional failure identified earlier:-

i) *Failure to Allocate Appropriate or Adequate Resources*

At Laguna Verde, 'Resources' applies to equipment, procedural documentation and personnel.

In equipment, there are many failures in the provision and correct identification of spare parts and maintenance is not properly resourced: For example, one single valve caused a reactor scram in 1994 and, although the problem with the valve was identified then, nothing was done until 1999 when a virtually identical scram was again caused by the same malfunctioning valve.

Technical and procedural support to the operatives is at a poor level if not, in some

critical areas, completely absent: The lack of rigid procedures seems to have seeded a novel mindset at the plant, inasmuch that in troubleshooting a demineraliser problem with the reactor at full power, the technicians not only adopted their own ad hoc procedures without a written plan but believed, totally against the administrative protocol of the plant, that a written plan was not required.

There were also major deficiencies in staffing: The simulator supervisors were so understaffed that they had little time to set up the simulator correctly to the extent that it operated in an unstable mode, thereby denying the staff effective and realistic training.

ii) *Failure To Acknowledge an Unsatisfactory or Deteriorating Safety Environment*

This relates to detecting and understanding 'warning signals' and, particularly, in amassing and reviewing past warning signals.

At Laguna Verde, the WANO inspectors expressed particular concern over the investigation of incidents in that *"root cause recommendations are sometimes ignored because of the available budget", "Repeat events may have occurred because corrective actions were not implemented", "Near miss events are not recorded", "the causes of the 1999 scram were never fully investigated", "* and that although in place, the Independent Quality Assurance group had *"issued 120 recommendations but, to date, no feedback from other station staff"* had been received.

In addition, the high incidence of defective instrumentation, temporary wiring installations, storage of combustibles in high risk areas, absence of disciplined preventative maintenance, etc., although readily identified by operatives on the ground neither they nor, as it seems, their supervisors were prepared to remedy these shortfalls. Individually, these defective and malfunctioning pieces of equipment might be considered niggling but, viewed collectively, such could represent a serious intrusion into the plant's safety capability.

The point here is that it seems that no individual at Laguna Verde seems to have been charged with and grasped the deterioration of the plant's overall safety environment.

iii) *Failure to Recognise the Limitations of the Safety Envelope*

Quite astonishingly, the WANO inspectors state that, on one hand, the senior supervisors considered that *"Safety culture is not a station recognised issue"* whereas, on the other, the Managers believed there to be a lack of safety culture at all levels, noting that although they felt responsible for safety culture they stated

that *"this was a new project and they had just started getting familiar with it"*.

Also, the WANO reports frequently touch upon the lack of expertise and training of the operatives, managers and supervisors at Laguna Verde. For example, in the key safety reactor engineering area, upon interviewing a reactor engineer, the supervisor and manager on the reactor event relating to on the fuel core load lines, the field reports concludes *"This is an example indicating a lack of fundamental reactor engineering knowledge"*.

The field reports also conclude that there is no formal training for reactor engineers, that there is too much reliance upon on-the-job training and, importantly, no individual is presently being trained up to replace *Reactor Engineering Supervisor* at his retirement in 1 year hence.

iv) *Production Imperative*

The sense of the production *imperative* is not discussed in the WANO field reports although there is an overriding impression that at Laguna Verde there exists an incentive to *get-the-job done come what may*.

This is illustrated by the lack of written procedures, the clearly reactive approach to maintenance,[8] group meetings at which open discussion is frowned upon and, what seems to be, the ineffectiveness of the root cause analysis, particular at its presentation and lack of implementation at the senior CROS level[9] because *"root cause recommendations are sometimes ignored because of available budget"*.

LAGUNA VERDE – AT THE CROSSROADS OF INSTITUTIONAL FAILURE ?

Obviously, organisational structure plays an important role in institutional failure: If the structure is too complex it is difficult to establish well defined rules and procedures that apply across a large number of organisational layers, but if overly simplified there may not be sufficient opportunity for checks and cross checks to be applied.

The organisational structure at Laguna Verde seems relatively straightforward but hierarchal, if not autocratic, in how it manages important safety issues. For example, the opportunity of senior supervisors to reject the root cause recommendations on budgetary grounds and that the independent quality

[8] And also ad hoc, particularly as reported for the electrical switching plant.

[9] Staff interviewed stated *"that root cause analysis personnel do not get any respect with making representations to CROS. They stated that CROS would often tell them that if they did not get to the root cause and [then] change the root cause. They do not argue with CROS because it is not good to buck the system."*

assurance group had received no feedback on any of the 120 recommendations, both suggest that the corporate management of the plant cannot or will not segregate safety from production and budgetary influences.

Moreover, there is the absurd difference of opinion between the line managers and the senior supervisors as to whether the safety culture is in place and adequate across the plant.

If this dichotomy stands then, together with the sense that the flow of information is only down from and not up to senior management, it suggests that the corporate management at Laguna Verde does not recognise that safety is not solely the responsibility of those at the man-machine interface.

Given this, the WANO field reports suggest that Laguna Verde is not simply in a morass but well on the road to institutional failure.[10]

[10] The text of the WANO letter to the plant operator of 7 January, 2000 is disturbing inasmuch that it states *"Issues such as those identified at Laguna Verde have existed at other nuclear stations in the past and still exist at other operating stations in North America today"* and *"As discussed with you . . . several plants in the United States and Canada are presently operating with a similar level of performance. These plants are currently operating with the full agreement of their governments, utilities, and WANO. In addition, a number of plants with the same level of performance have been operated in the past".*

PART II ASSESSMENT OF THE WANO REPORTS IN DETAIL

Breaking down the WANO field reports into the relatively broad categories of maintenance, setting down of work and quality control procedures, spare parts management, training, health and safety and forward planning:-

TABLE 1 – SUMMARY OF LAGUNA VERDE WEAKNESSES

HEADING LEGEND:

A	MAINTENANCE FAILURES
B	LACK OF PROCEDURES
C	SPARES SHORTAGES
D	LACK OF TRAINING AND HUMAN ERRORS/OMISSIONS
E	FAILURES IN HEALTH AND SAFETY HOUSEKEEPING
F	ABSENCE OF FORWARD PLANNING

WANA Review Group	No	Examples	A	B	C	D	E	F
EQUIPMENT PERFORMANCE AND MATERIAL CONDITION & EMERGENCY STANDBY AND NUCLEAR EQUIPMENT MALFUNCTIONS AND SHORTFALLS	1	During the past two years (1998-99) there occurred 3 failures of the emergency diesel generator cover; 5 incidence of serious equipment problems in the reactivity management systems; 7 problems with equipment resulting in loss of generation, extended outage and reactor shutdowns; and 2 incidences where radioactivity cross a barrier containment. As a result of either poor or omission of *regular and preventative maintenance*, all of the emergency generator failures stemmed for failure to adequately maintain the plant, particularly the electrical switchgear; there was one incident of a reactor recirculation pump failure to include the speed permissive relays in the preventative maintenance programme; and air entrainment into the primary circuit because a valve had not been refitted with a gasket. *Operator error and/or inadequate training* resulted in, when endeavouring to identify a fault in the demineralizer system with the reactor at full power, the operatives went about the troubleshooting without a written plan, which was required by the plant administrative protocol, although the operating personnel did not believe that a plan was required.	✓		✓	✓		
ELECTRICAL SWITCHING EQUIPMENT	2	As well as the somewhat ramshackle condition of the electrical switching area and a number of shortfalls relating to health and fire safety, there are no *emergency actions procedures* in place and the operator of the control room had received *no training* in the switching control room procedures.		✓		✓	✓	
EQUIPMENT PERFORMANCE TESTING	3	No test procedure available for the room coolers		✓				
PREVENTATIVE MAINTENANCE PROGRAM AND REPORTS, MAINTENANCE PACKAGE	4 29 30 34 35 39	There is no documented technical basis for the Preventative Management Program, no cross connection of failures on similar systems, unauthorised work undertaken by operatives, and workers do not always follow written work instructions, sometimes incomplete written instructions	✓	✓			✓	✓
REACTOR BUILDING CONDITION	5	Leakages in both RHR A and B rooms of Unit 1 are radioactively contaminated, one hot spot is marked at 6mSv/hr dating from December 1998, the sources of contamination have not been identified and there other examples, such a only 1 light working out of 5 in the valve room, all of which suggests that *maintenance* and *housekeeping* is neither routine or effective.	✓	✓			✓	
HEATER DRAIN SYSTEM	6	Lack of *forward planning* and *spares shortages* is where a heater drain system valve which initiated a reactor scram in 1994 but was not replaced then nor had been replaced/repaired through two successive refuelling outages and, in fact, this same valve initiated a reactor scram in 1999 that was virtually identical to the 1994 scram.			✓			✓
REACTOR REFUELLING	7	A number of examples show that the *training and monitoring techniques and procedures* adopted by operatives, technicians and supervisors are insufficient to prevent the spread of contamination.		✓			✓	

SAFETY CULTURE	8	Shortfalls identified in lack of effective supervision specialist and first –level managers		✓				
OPERATOR EXPERIENCE	9	Lack of coordination between databases, no discussion of operating experience at the morning meetings, no self-evaluation programmes in place, no priority established for operating experience.		✓				
CORRECTIVE ACTION	10	Near miss events not recorded		✓				
ROOT CAUSE	11	Root cause analysis failing to correctly identify the cause problems, operatives untrained with analysis equipment, long delays if root cause outcome		✓				
FEBRUARY 1999 SCRAM	12	All contributory causes of scram not evaluated		✓				
GROUP INTERVIEWS SUPERVISORS', MANAGERS AND TRAINING INTERVIEWS	13 14 15 16	Supervisors do not believe safety culture to be a station issue but Managers believe there to be a lack of safety culture at all levels. No human performance assessment system established. Station training programmes not implemented in a timely manner and inadequate procedural guidance.		✓				✓
SELF EVALUATION	17	There is no focused self-evaluation programme		✓				✓
CHEMISTRY DATA REVIEW CONTROL AND FEEDWATER SAMPLING, PURIFICATION	18 19 20 21	Excessive frequency of chloride spiking related to poor maintenance and abnormal chemistry data and events not highlighted, may equipment leaks of oil and hydraulic fluids, combustible materials present in chemical stores, lack of protective clothing, and failures of equipment and unsatisfactory temporary modifications	✓	✓	✓	✓	✓	✓
CONDUCT OF ENGINEERING	22	Root cause analysis unsatisfactory for Engineering		✓				✓
REACTOR ENGINEERING ENGINEERING RECORDS	23 24	Absence of procedures shows lack of fundamental reactor engineering practical knowledge, no formal training for reactor engineers and strong reliance upon on-the-job training, no individual being trained up to replace Reactor Engineering Supervisor upon his retirement in 1 year hence, and radiological health and safety issues present. Engineering drawing record and revisions incomplete		✓			✓	✓
SYSTEMS ENGINEER INTERVIEW	25	No formal training for the diesel generators, possible problems wit h the emergency air starting procedures		✓			✓	
SPARE PARTS CONTROLS	27	Incorrect identification of spare parts.	✓	✓	✓			
REACTOR BUILDING VENTILATION	28	Spare parts shortages and problems of identification, health and safety issues	✓	✓			✓	
MAIN STEAM RELIEF VALVE TEST	32	Health and safety concerns					✓	
HOUSEKEEPING	33	Requires improvement					✓	
FASTENERS	36	Some fasteners on equipment missing and screw threads insufficiently engaged	✓					
CRANES	37	Overhead cranes in the steam relief valve test area had never been tested and no preventative management had been performed o n the refuelling machine brakes	✓	✓			✓	
WIRE SPLICING	38	Incorrect techniques result in health and safety hazard		✓			✓	
OFF GAS SYSTEM	39	Pre-Job briefings did not include for discussion of health and safety matters		✓			✓	
PLANNING	40	Work Packages delivered at last minute, no tool list within package	✓					✓
PRIORITISATION OF MAINTENANCE WORK	41	Generally, everything is over-prioritised		✓				✓
INDEPENDENT SAFETY ANALYSIS GROUP	42	No program quality review undertaken, issued 120 recommendations but, to date, no feedback for other station staff					✓	
FIR E PROTECTION RESPONSE	44	Fire protection personnel slow in response		✓				
SIMULATOR CREW PERFORMANCE AND EVALUATION	45 57	Lack of simulator capability, broken instrument panels and shortage of information and crew response in error because reactivity management standards are incomplete, simulator has defects and identical scenarios of Units 1 and 2 produce different reactions. Staff shortages on training and unrealistic and/or unstable preset conditions preset by the simulator supervisors reduce the effectiveness of the training and evaluation of operators.		✓			✓	
NUCLEAR OPERATIONS WORKS ACTIVITIES	46	Longstanding equipment problems cause a scram, some safety reviews on feedwater heater controls	✓	✓			✓	
ORGANISATION AND ADMINISTRATION	47	Personality conflicts between managers and higher authority, the reactivity management indicator is inaccurate and the target is too liberal at one reactivity event per month, human performance indicator is also inaccurate, no method of reviewing maintenance backlogs available	✓	✓				✓

MAIN CONTROL ROOM CONDITION	48	Ancillary equipment not seismically fastened, several leaking safety relief valves left leaking over 7 month period, inadequate neutron monitoring for conditions below hot shut down, and the number of lit and defeated alarms is far too high and many alarm deficiencies are not identified with problem tags – root cause of June 1999 scram not fully investigated	✓	✓		✓		
OPERATOR ROUNDS HUMAN REVIEW ACTIVITIES	49 50 51	Longstanding equipment problems not addressed, operators adopted unwritten procedures,	✓	✓				
RADIATION EXPOSURE CONTROLS CONTAMINATION CONTROL INDUSTRIAL SAFETY CONDENSATE FILTER REPLACEMENT DOSIMETRY	52 53 54 55 56 58	2 areas of high radiation previously unidentified, high level items in pool not identified, filter float problem in pools, and some radiological controls insufficient to prevent unplanned exposures, many personal contamination incidents were not recorded, and many work practices could contribute to the spread of contamination, workers received additional radiation exposure because they were inexperienced		✓		✓	✓	
TRAINING	59 60 62	System engineer training not systematically developed and not consistent with the job, engineering experience is not transmitted across to the training department, emergency preparedness in engineering is incomplete, no worker qualification list exists, all manufacturing and vender manuals are in English, no overhaul plan for the diesel air compressor, operator experience not systematically included in the training programme		✓		✓		