IAEA/UNDP-CPR/91/221 -01
Technical Report 1

MANPOWER DEVELOPMENT FOR SAFE OPERATION OF NUCLEAR POWER PLANT

CHINA

MAIN STEAM BYPASS SYSTEM OPERATION AND MAINTENANCE

UNITED NATIONS DEVELOPMENT PROGRAMME
INTERNATIONAL ATOMIC ENERGY AGENCY

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MAIN STEAM BYPASS SYSTEM OPERATION AND MAINTENANCE (TASK: 6.1.6)

Report prepared for
the Government of China

by

the International Atomic Energy Agency
acting as Executing Agency for
the United Nations Development Programme

UNITED NATIONS DEVELOPMENT PROGRAMME
INTERNATIONAL ATOMIC ENERGY AGENCY

VIENNA 1994

Stubley Energy Associates

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China Manpower Development For NPP Operation

Main Steam Bypass System Operation And Maintenance

1993 October 18 to October 29

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EXECUTIVE SUMMARY

This mission concentrated on the Steam Bypass system of Qinshan Nuclear Power Plant. The system had experienced spurious opening of the bypass valves, disrupting the steam pressure control and the steam generator level control system. A series of commissioning type tests were defined which should allow the operators to revise the setpoints used in the control of the bypass system, and thus prevent spurious opening while maintaining the desired steam pressure control during power manoeuvring.

Training of operations personnel in the function of the bypass system was included in the mission to ensure that the system is understood, and that the system with its control setpoints and its components will be properly maintained.

Training also included giving experience from other operating plants on aspects of steam and feedwater systems and components, especially as this experience affected maintenance or gave rise to problems. Steam generator maintenance experience is especially applicable, and a future mission is planned for an expert in this field.

In addition other aspects of the Chinese nuclear program was assessed to guide future missions. This included assessment of operating procedures from an availability point of view. (Content could not be judged because of the language barrier). An assessment was also made of the availability of design support to site, when a problem does occur. Adequate support exists now, but the design organization is experiencing a greatly increased workd and responsibility, which may jeopardize their future support capability.

The Chinese staff, and indeed all the Chinese people I came in contact with, were very helpful and friendly. They seem to appreciate our efforts to help.

WORKSHOP ADMINISTRATION FACTORS

Arrangements

My hosts did everything possible to make the experience enjoyable and comfortable. Food and lodging were the best available at site. Transportation was provided wherever required by their company car.

Objectives

This workshop had two basic objectives: (a) first to ensure the Chinese operators understood what the system was supposed to do, and how it accomplished it, and (b) second, to assess why the system did not seem to act as required, an d define a fix. Experience on similar systems in other water reactors was used to demonstrate some of the operating characteristics and some of the potential problems in such systems.

Secondary objectives included: provide experience in other systems and components associated with the steam and feedwater systems, to help them prepare objectives for maintenance procedures; assess their operating protocols for ability to handle problem situations, including the availability of support to site operations from their design staff.

Participants

There were 18 full time participants, including three senior engineers, the Deputy General Engineer, Chief of Maintenance Dept, and Head of Training Centre.

The Chief Design Engineer of the Conventional Island from Shanghai Institute was present for most of the sessions, and was invaluable in sorting out the problem.

Three of the engineers acted as translators, and because they understood the technical arguments they could translate effectively.

During some special topics (eg Steam generator maintenance) other personnel from the plant joined the workshop.

I have a list of the participants but it is in Chinese and only partially translated, so is unintelligible to me.

Agenda

The agenda is attached as Appendix 1. It was developed during the program, because the objectives were not able to be defined before reaching site and discussing them with the hosts. The original agenda was vague on what to do re solving the Steam Bypass problems, because it was not clear that I would have the expertise to solve the problems once they were identified. I believe that ultimately we were able to define a solution which will give satisfactory results.

Resources Available

Facilities for lectures were good. They have a training facility set up which has adequate desks, blackboards and overhead projector. They have earphones for simultaneous translation, but we did not use this feature. Three of the younger participants who were knowledgeable in the bypass system also had sufficient English skills to act as translators. Language was difficult because very few in the workshop had a working knowledge of English, especially the senior people, and no one had complete English skills.

There was a lack of personal computing/typewriter facilities. I had to rely on my penmanship which is atrocious now. A laptop would have been an asset. The instructions I left for the test program is handwritten, and then will be transl ated in Chinese. I hope it doesn't lose too much in the translations.

I had difficulty digging out adequate documentation to describe the bypass system. They seem to be using Chinese translations, and I wanted the original English/German documents. We eventually got enough to understand it.

Highlights

As part of the mission I tried to assess several areas of their operations which could possibly make use of international help. My observations and recommendations follow.

1. Operator Training - Abnormal Operating Procedures

The operating personnel in the control room seemed to feel they were adequately trained, and had adequate abnormal operating procedures available. They were able to show me several volumes of Abnormal Operating procedures available in the control room.

They also have planned a full scale mockup of the control room for operator training. It is expected to be ready next year, and will support their expansion programs both in China and offshore.

No specific recommendations in this area.

2. Maintenance Procedures

The site personnel are not as confident in themselves in this regard. They feel confident in most areas, but recognize that help would be useful in some areas.

Steam Generator maintenance is a worry, because chemistry control is such a big factor. They also have not had direct experience in actual maintenance procedures on active operating units. I agree that an expert in this area could help them.

I also suggested that international bodies and technical societies have significant information available, and they should join and participate in these organizations. Examples are: INPO, EPRI, ASME Conferences, (a recent conference on Steam Generator Maintenance sponsored by Canadian Nuclear Society CNS had significant useful information and experience presented.)

Planning for maintenance outages was also discussed. They feel that assistance in the Quality Assurance aspects and the Safety issues of refuelling outages would be of assistance to them. An expert from PWR operations could be useful to them in this area.

3. Technical Support From Designers

The design office is just over two hours away by car, and they have good telephone and fax communication links. The technical support has been as good as possible I feel. The senior personnel in the design office have many years experience in nuclear design, but naturally not much experience with operating plants.

I have a concern that the availability of technical support will decline to less than adequate, due to the anticipated workload on the design staff. The design organization in Shanghai, (SNERDI) is accepting significant new responsibilities, including:

- design and construction of two more units at Qinshan
- design and construction for a Pakistan unit
- technical support to Daya Bay as well as Qinshan
- feasibility studies for several other provinces

Based on the Canadian experience at the same stage of the national program, I would expect that their design organization will have to grow from the present 900 to about 3000 people. This could be a major problem in (a) availability of personnel for technical support to Qinshan, and (b) technical experience and competence of the design staff which would be made available as support personnel.

SPECIFIC RECOMMENDATIONS TO CNNC

1. Perform tests on Steam Bypass System as outlined by expert. Set operating parameters and assess performance of the system. If system operation is still unsatisfactory, consider obtaining services of a control expert.

2. Join and participate in International technical bodies, such as WANO, ASME, EPRI (if possible).

IAEA Sponsored Workshop
Main Steam Bypass System
Qinshan Nuclear Power Plant

1993 October 17 to October 29

A G E N D A

October 18	morning	.Travel from Shanghai to Qinshan
	1330 -1630	.Meet senior staff at Site, tour of plant. .Agree on Agenda
October 19	0800 -1130	.Introduction of Specialist. .Introduction of Participants .Main Steam Systems and General Requirements of Steam Bypass System
	1330 -1630	.Typical Steam Bypass System .Control Systems for Steam Bypass
October 20	0800 -1130	.Reactor and Turbine Energy Balance .
	1330 -1630	.Operating Requirements for Steam Bypass Valves .
October 21	0800 -1130	.Qinshan Steam Dump System Description .(Mr Fan Qihua, Dir.Conventional Island Design) .Actual Operation vs Desired Operation .Define Information Needed
	1330 -1630	.Plant Tour of Steam Bypass System, .Control Room, and Operating Procedures
October 22	0800 -1130	.Steam Generators - design, operational .maintenance, tube inspection, leak detection, .Valves - check valves, counterweights, shaft seals
	1330 -1630	.Define Steam Bypass Problems in Detail .Identify Implementation of Likely Fix
October 23,24	In Shanghai	
October 25	0800 -1630	.(In Shanghai) Review Sulzer Information .Prepare Recommendations
October 26	0800 -1200	.At SNERDI (Shanghai Institute) Discuss .recommendations with Mr Fan Qihua and Institute designers.

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	1300	.Travel to Qinshan
October 27	0800 -1130	.Present Recommendations to Site Personnel .
	1330 -1630	.Discuss Recommendations .
October 28,29		.Write Recommendations, Prepare Translation .Closing Ceremonies

ASSESSMENT OF STEAM BYPASS SYSTEM

The steam bypass system was assessed to determine its basic ability to meets its design requirements, and to determine how it could be made to meet these requirements in service.

1. Philosophy of Bypass Valve Requirements

a) Be able to control pressure in steam system to an acceptable maximum pressure during abrupt changes in system operation, without causing unacceptable boiler level excursions.

b) During operation with no turbine load, or turbine load intentionally less than reactor power (eg during startup) be able to control pressure to the desired level during steady state and power manoeuvring with acceptable quick response time and acceptable hunting characteristics.

c) During power manoeuvring with small changes (less than 10% full power) allow the reactor control system to handle the change without opening the bypass system. If the reactor trips on power manoeuvring, then the bypass should take over.

d) Do not operate the bypass when conditions would jeopardize other systems or components, (eg loss of condenser vacuum).

2. How the existing system design achieves these objectives.

Meeting a) above
- Provide fast opening capability (3 seconds to full open)
- Act on steam pressure rise, giving fast response, and responding to disturbance no matter how caused.
- Modulate flow by number of valves opening (one to four)

Meeting a) plus c) above
- Do not open if pressure rise is less than that associated with a 10% change in reactor power.

Meeting c) above (modulating control)
- Act on signal from steam pressure, Reactor power (Tav), and Turbine power (1st stage turbine pressure), through PID controller (Proportional, Integral, Differential).
- Slow response time (up to 20 seconds) makes smooth response easily accomplished, and allows reactor control system to respond.
- Feedback term (Integral) prevents overshoot of control.
- Feedforward term (Differential) anticipates pressure due to turbine governor or stop valve action. Target setpoint matches required setpoint as valves are opening.

Meeting b) plus c) above.

- The first valve opening setpoint has a deadband equivalent to that associated with a 10% reactor power change. Therefore it will not open if the reactor follows the turbine load within this deadband.

PROBLEMS

There were two problems identified by the participants in the workshop. The first problem had already been solved, but was discussed anyway.

1) On changeover from manual to auto operation during the transition to bring the turbine on line, there could be a mismatch. A change in operating procedures had already solved this problem.

2) Spurious fast open signals caused a valve to open when the power mismatch was less than the 10% deadband design. Closing after clearing of the spurious signal was slow, governed by the modulating circuit, not the fast open circuit. The slow closing contributed to a significant loss of steam, disrupting the steam system pressure and the steam generator level control system. This problem occupied a significant portion of the workshop time and effort.

SOLUTIONS

I identified several possible approaches to a solution to the spurious opening problem. These are identified below, with the first one being the one recommended.

1. Raise the set point on the steam pressure signal at which the valve will act in the 'fast open' mode.

The peak pressure must be defined which occurs during a small power reduction transient. This is a transient which is small enough that the valve is not desired to open. A test program was defined which would give these results, and site were prepared to perform these tests at the earliest convenient time. They would likely be performed in conjunction with a planned shutdown, to alleviate any lost production if the system responded by shutting the plant down, instead of just reducing power to a new lower value.

2. Revise the valve control system so the 'fast open' signal responds to a mismatch between turbine first stage pressure (equivalent to turbine power) and Tav (equivalent to reactor power). This is the configuration that the operations personnel are familiar with in the plants on which they trained.

The advantage is that the system would respond in the same manner for both the 'fast open' mode and for the 'modulating' mode, possibly making it easier to set the parameters.

However, a complete reassessment of all the parameters would be required anyway, and would likely take as much or more effort than option 1. In addition there would be a significant loss of operating time during the time required to perform the actual modifications to the control system and to check it out for adequate quality assurance.

A small disadvantage to this option is that the 'fast open' mode would respond only to power mismatch between the turbine and the reactor. It would not respond to steam pressure fluctuations caused by other processes, eg main steam safety valve closure, feedwater heater isolation, etc. Option 1 responds to pressure fluctuations no matter what the cause. In either case, the modulating mode will take over the main control parameters after 20 to 30 seconds.

3. Increase speed of response of the 'modulating' mode.

Two results are possible. (a) If the modulating response time can be made fast enough, then the 'fast open' mode may not be necessary, thus eliminating the spurious response. (b) The problem of 'fast open' followed by 'modulating mode' closing on a spurious signal would be alleviated, if not eliminated. This reduces the negative effect of a spurious opening.

A problem with this approach is that, if the steam bypass system responds faster than the reactor control system, then the reactor may not respond to power reductions in the turbine.

RECOMMENDATION

1. I recommended that tests be performed which would define the pressure transient that occurs when the power of the turbine is lowered by an amount that should <u>not</u> make the bypass system respond. Power reductions are to be made with the steam bypass system blocked from acting in the 'fast open' mode for one valve only, (the first valve to open). This will still allow the protective function to operate, but will prevent a spurious opening. Measurements of steam pressure vs time during the transient are to be made, and from these a new setpoint can be defined which will allow the system to respond as designed.

Several sets of tests are required to define the setpoints for one, two or three valves in the 'fast open' mode.

The test series proposed is designed so that the first tests have a smaller likelihood of causing a spurious shutdown of the plant, thus giving operations the best chance of gaining the maximum required information without loss of production.

2. I also recommended that the response speed of the modulating mode be assessed during the tests. Note that because the bypass system has not operated satisfactorily because of the 'fast open' spurious signals, the modulating mode has not been properly commissioned either.

3. If the system operates satisfactorily as a result of these tests and new setpoints, then the problem has been solved simply. If not, then the problem is one of control logic. In that case I would recommend that a control expert be engaged to assist in solving this aspect of the problem. Hopefully that will not be necessary.

P.H. Stubley
IAEA Consultant

October 1993