MODULE 1

MANAGEMENT OF A NUCLEAR POWER PLANT

MANAGEMENT OF NPP MAIN TOPICS

- The Management Process
- Major influences on todays NPP management process
- Management objectives:
  - Employee safety
  - Public safety
  - Reliability
  - Business performance
  - Environment

OPERATION & MAINTENANCE OF NPP MAIN TOPICS

- Station organization
  - Functions of main groups
- Implications for operation of NPP
  - Operating license
  - Financial aspects and costs
  - Elements of OM &A
  - Capital Depreciation
  - Cost model

THE MANAGEMENT PROCESS

- Three steps:
  - Where do you want to be?
  - Where are you now?
  - What resources need to be applied?

MAJOR INFLUENCES ON NPP MANAGEMENT PROCESS (INPO)

- Pre Three Mile Island:
  - Minimum regulatory requirements
  - Fragmented approach to business
  - Independent, working in isolation
- T.M.I.
  - 'Hostages of each other'
  - NRC threat
- Post T.M.I.
  - Self regulation and road to excellence

CIRCUMSTANCES THAT LED TO THE CREATION OF INPO

- Before the Three Mile Island incident, the nuclear industry basically managed to meet the minimum requirements of the regulators. It was fragmented and independent.
- (March 28, 1979) Three Mile Island put the industry in a fish bowl. The industry recognizes that they were "hostages of each other", i.e. if one makes a mistake, they all pay the price. Also, Nuclear Regulatory Commission were considering tight regulatory restrictions.
- (December 3, 1979) Institute of Nuclear Power Operations was formed to self-regulate -- to put the industry on the road to excellence.

MAJOR INFLUENCE ON NPP MANAGEMENT PROCESS (INPO)

- INPO Regulatory Norms
  - Performance Objectives
  - Criteria
  - Guidelines
  - Good Practices

MAJOR INFLUENCE ON NPP MANAGEMENT PROCESS (INPO)

- Benefits of Self-Assessment
  - Criteria for Self-Assessment
  - Benchmarks for Excellence
  - Shared Experience
  - Mutual Support

INPO

Unlike the regulator INPO does not produce prescriptive standards that must be stringently adhered to. Rather, it provides benchmarks for excellence that reflect the best standards achieved to date.

INPO emphasizes the achievement of performance objectives. The criteria outline the various tasks normally required to achieve a given performance objective. Methods for achieving the desired results are generally not stated, so considerable judgment is required in applying the criteria. Guidelines on the criteria capture a great deal of operating experience. INPO'S good practices are based upon the industry's most successful plants and provide a model for success.

The benefits of INPO are reflected in the improved performance of U.S. nuclear plants since TMI.

The challenge in any NPP is to achieve the same level of nuclear excellence when benchmark against the U.S. best performers.

MANAGEMENT OBJECTIVES

- Management performance is measured by the key result areas (KRA)
  - Employee safety
  - Public safety
  - Reliability
  - Business performance
  - Environment

KEY RESULTS AREAS

What are these Key Result Areas (KRA's)

SAFETY;

As long as management continues to focus on the safety and well being of the employees and the public, major nuclear accidents will not occur.

Managers and supervisors must be constantly aware of the potential danger and consequence of unsafe practices. It is in this regard that the INPO philosophies encourage organizations to constantly strive for excellence at all levels of staff.

No amount of effort must be spared, as the responsibility of running a nuclear power plant is tremendous. Society accepted the assurances of the industry, and this trust must never be lost.

RELIABILITY;

It is the business of making sure everything works well. It is ensuring that all the equipment and systems, are robust, withstand shock, do not deteriorate, carry out the intended functions well when called to operate, and give some kind of indication if they are about to fail.

It is the process of equipment selection and maintaining the 'as new' performance over the life of the plant. It is selecting the correct equipment for the required job, e.g. a locomotive cannot be stopped using automobile breaks. It is having systems that can function for longer times than the shutdowns require to repair them, and to produce plant capacity factors to achieve a business that is economical.

BUSINESS PERFORMANCE

- The business performance covers a wide range or issues such as:
    - Documentation updates
    - Control of jumper
    - Training of staff
    - Radiation exposures
    - Infringements of Policies & Principles
    - Compliance with local regulation & by-laws

- The financial health of the business covers such things as:
    - Budgeted OMB expenses - actual/planned
    - Capital improvement programs - actual/planned
    - Heavy water losses
    - Fuel burn up

- The following costs are important:
    - Production costs for unit energy
    - Total costs for unit energy
    - Capacity factor
    - Planned outage time
    - Unplanned outages

ENVIRONMENT

It is of vital importance to monitor the effects on the environment local to the power plant. The following are the types of parameters monitored closely.

Radiological discharges:

- Solids
- Liquids
- Gases
- Temperature impact of discharge water
- Noise impact of plant operation
- Radiological waste treatment
- Irradiated fuel management

STATION ORGANIZATION

- Modeled on a single unit 1 X 7220 MW with on site independence
- Examples of such Nuclear Stations are:
  - Point Le Preau - Canada
  - Gentile 2 - Canada
  - Wolsong 1 - Korea
  - Embalse 1 - Argentina

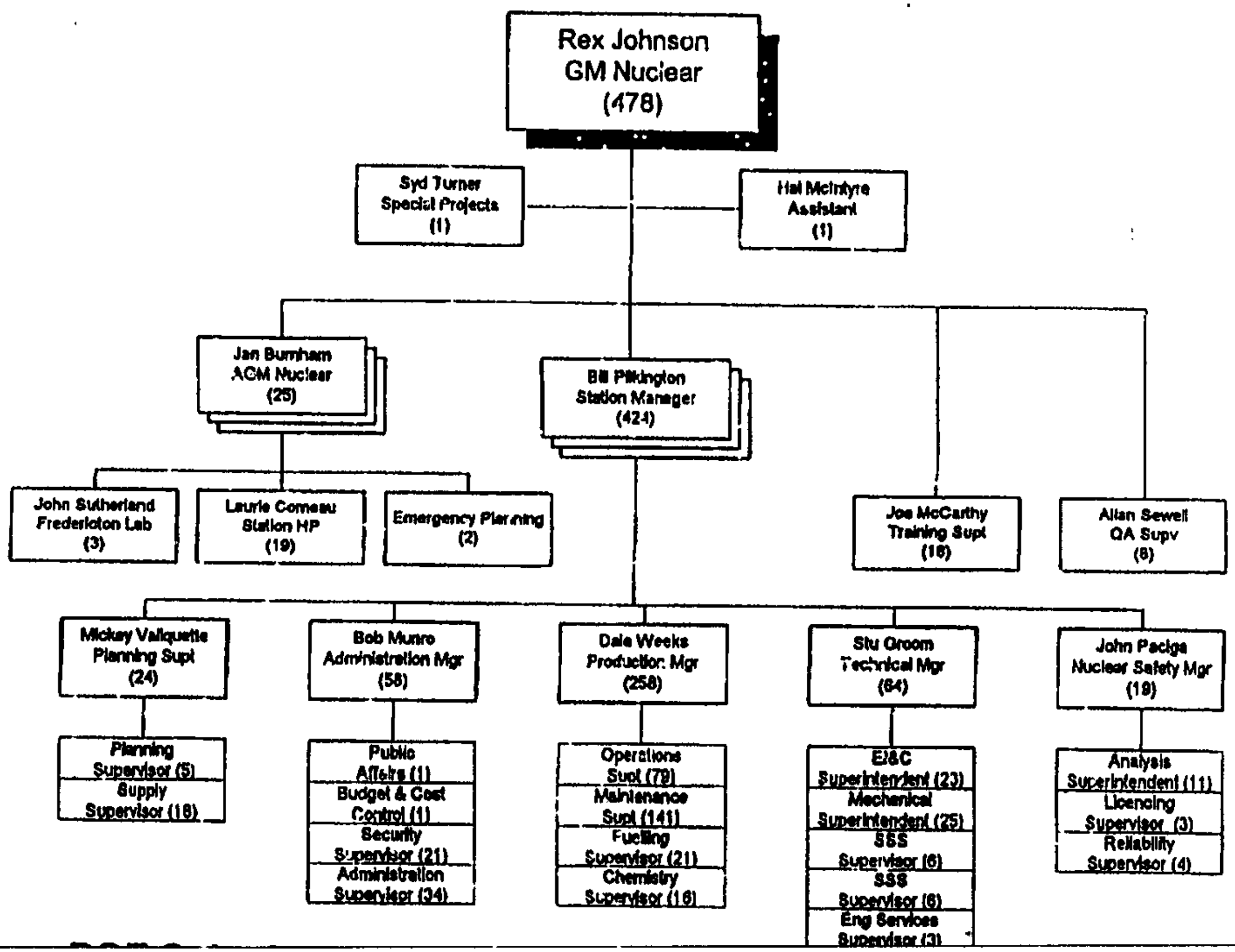
STATION ORGANIZATION

- The total station staff is approx. 500
- The station capacity factors lifetime > 85%
- No major refurbish programs are considered.

STATION ORGANIZATION

- Examine the organization & responsibilities of the following:
  - Operations
  - Maintenance
  - Technical
  - Planning
  - QA
  - Training
  - Health Physics

- MANAGEMENT FUNCTIONS
- STATION MANAGER
- PRODUCTION MANAGER
- SHIFT SUPERVISOR
- MAINTENANCE SUPERINTENDENT
- TECHNICAL MANGER
- PLANNING GROUP
- ADMINISTRATION GROUP
- QA GROUP
- HEALTH PHYSICS
- TRAINING GROUP


Rex Johnson
GM Nuclear
(478)
Syd Turner
Special Projects
(1)
Hal McIntyre
Assistant
(1)
Jan Burnham
ACM Nuclear
(25)
Bill Pilkington
Station Manager
(424)
Joe McCarthy
Training Supt
(16)
Allan Sewell
QA Supv
(8)
John Sutherland
Fredericton Lab
(3)
Laurie Comeau
Station HP
(19)
Emergency Planning
(2)
Mickey Valliquette
Planning Supt
(24)
Bob Munro
Administration Mgr
(58)
Dale Weeks
Production Mgr
(258)
Stu Groom
Technical Mgr
(64)
John Paciga
Nuclear Safety Mgr
(19)
Planning Supervisor (5)
Supply Supervisor (18)
Public Affairs (1)
Budget & Cost Control (1)
Security Supervisor (21)
Administration Supervisor (34)
Operations Supt (79)
Maintenance Supt (141)
Fuelling Supervisor (21)
Chemistry Supervisor (16)
E/&C Superintendent (23)
Mechanical Superintendent (25)
SSS Supervisor (6)
SSS Supervisor (6)
Eng Services Supervisor (3)
Analysis Superintendent (11)
Licencing Supervisor (3)
Reliability Supervisor (4)

MANAGEMENT FUNCTION

- Establishing procedures to ensure that documentation correctly reflects the field status.
- Maintaining adequate records of commissioning, operating and maintenance activities.
- Verifying procedures and field activities to ensure that the right thing is done at the right time in the right way.

MANAGEMENT FUNCTION

- Systematically reviewing commissioning completion assurance at appropriate stages during commissioning.
- Auditing the quality assurance program to independently confirm that the right thing is being done at the right time in the right way.
- Periodically reviewing the effectiveness of the QA program.

STATION MANAGER RESPONSIBILITIES

- Authorize overall organizational structure.
- Define section responsibilities.
- Define specific position responsibilities to first level of supervision.
- Commissioning completion assurance.
- Significant event reports.

STATION MANAGER RESPONSIBILITIES

- Operating manuals
- Abnormal incidents manual
- Radiation protection procedures
- Work authorization
- Work protection
- Use of jumpers

STATION MANAGER RESPONSIBILITIES

- Surveillance, Routine testing and Periodic Inspection
- Maintenance program
- Audits
- Change controls
- Quality assurance records

PRODUCTION MANAGER RESPONSIBILITIES

- Commissioning completion assurance
- Planning and scheduling of field work
- Station logs
- Signification event reports
- Operating manuals
- Abnormal incidents manual

PRODUCTION MANAGER RESPONSIBILITIES

- Radiation protection procedures
- Maintenance procedures
- Operating memos
- Work protection
- Use of jumpers
- Maintenance Program

PRODUCTION MANAGER RESPONSIBILITIES

- Housekeeping
- Audits
- Change controls

SHIFT SUPERVISOR RESPONSIBILITIES

- Operating policies and procedures
- Equipment Identification
- Nuclear prescribed substance control
- Station logs
- Significant event reports
- Operating manuals

SHIFT SUPERVISOR RESPONSIBILITIES

- Maintenance program
- Housekeeping
- Security
- Deficiency reports
- Change controls
- Work on pressure boundaries

MAINTENANCE SUPT. RESPONSIBILITIES

- Maintenance Programs
  - Preventative maintenance
  - Predictive maintenance
  - Specialized skills training
  - Specialized tools
  - Maintenance procedures
  - Spare parts
  - Maintenance standards & practices
  - Identification of capital improvements projects

TECHNICAL MANAGER RESPONSIBILITIES

- Station logs
- Significant event reports
- Technical reports
- Abnormal incidents manual
- Work protection
- Use of jumpers

TECHNICAL MANAGER RESPONSIBILITIES

- Surveillance, Routine testing and periodic inspection
- Maintenance program
- Audits
- Change controls
- Work on pressure boundaries
- Feedback

TECHNICAL MANAGER RESPONSIBILITIES

- Correlation to other standards
- Commissioning documentation
- Turnover procedure
- Commissioning completion assurance
- Equipment identification
- Callups and routines

TECHNICAL MANAGER RESPONSIBILITIES

- Environmental qualification of safety related equipment
- Nuclear prescribed substances control
- Technical reports
- Operating manuals
- Abnormal incidents manual
- Operating flowsheets
- Maintenance procedures

PLANNING GROUP RESPONSIBILITIES

- Commissioning completion assurance
- Initiation of field work
- Planning and scheduling of field work
- Callups and routines
- Station logs
- Surveillance, Routine testing and periodic inspection

PLANNING GROUP RESPONSIBILITIES

- Maintenance program
- Housekeeping Audits
- Deficiency reports
- Change controls

ADMINISTRATION SERVICES

- Staff Services
- Payroll
- Accounting
- Administrative Services
- Information Technology
- Material Management
  - Procurement
  - Storage
  - Supply

QA RESPONSIBILITIES

- Prepare QA manuals
- Audit Business Process to assure all relevant standards are applied & complied with
- Report findings to Station Manager
- Make recommendation for QA aspects
- Provide QA training

TRAINING GROUP RESPONSIBILITIES

- Provide training programs for
  - Licensing staff
  - Operators
  - Maintenance staff
  - Technical staff
  - Business Administration staff
  - Manage & maintain simulator(s)
  - Manage & maintain training facilities
  - Maintain records of staff competency

HEALTH PHYSICS RESPONSIBILITIES

- Provide services to line management for all radiological aspects of plant operation & maintenance.
- Provide specialized services for 'high hazard work'
- Prepare emergency preparedness procedures & provide training.
- Provide radiation protection training

HEALTH PHYSICS RESPONSIBILITIES

- Make recommendations on the use & application of radiation monitors & instruments.
- Evaluate the effectiveness of station radiation monitoring program.
- Provide services for staff dose measurements & records.

IMPLICATIONS FOR OPERATION OF NPP

- The major influences which require balancing in order to make a nuclear power plant viable are:
  - Operating license
  - Financial aspects of various costs
  - Various element of OM & A costs
  - Capital improvements
  - NPP operating cost model

OPERATING LICENSE

- The operating license is issued by the regulator authority.
- It is quite specific, lays out terms and conditions that must be met.
- The owner does not have a free hand.

OPERATING LICENSE

- Governs such things as;
  - Staffing levels
  - Staffing qualification
  - Operating practices
  - Limitation on system operation
  - Testing requirements
  - Maintenance requirements
  - Security

OPERATING LICENSE

- Governs such things as;
  - Handling of prescribed substances
  - Transportation of radioactive material
  - Reporting to licensing authority
- The specifics of operating license will be covered in detail under configuration management.

COST COMPONENTS OF ENERGY

- The cost components of energy from a nuclear generating station are divided into three main components:
  - Capital costs
  - Fuel costs
  - Operating, maintenance, and administration costs

3. THE COST COMPONENTS OF ENERGY FROM A CANDU NUCLEAR GENERATING STATION

The cost of electricity produced at a nuclear power station is made up from the components of cost to build and operate the plant. This is generally divided into three main components, Capital Cost, Fuel Cost, and Operating Maintenance and Administration (OM&A) Costs.

Utilities have various ways of accounting for cost by breakdown into various categories and some differences in accounting practices exist from one utility to another. However, all utilities have the same general components of cost although the amounts (or percentages of the total) vary to some extent depending upon whether the station is single or multi unit, and whether the utility has other nuclear stations which will share in some of the costs common to all stations.

For the purposes of illustrating OM&A costs distribution, Point Lepreau has been chosen as the example and the costs are based on those incurred in the fiscal year 1994/95 (which is the latest year for which complete and detailed costs are available).

3.1 Capital Cost

The largest component of cost is the initial capital cost of the Station. The capital cost is normally determined when the station first enters commercial service. This date is usually called the "In Service Date". The capital cost is paid back over the financial life of the station (typically 30 or 40 years) by means of a depreciation charge against the station. The interest on the outstanding debt (capital cost less depreciation) is also charged against the station and this interest charge reduces with debt. Two general methods of depreciation are followed. Straight line depreciation causes the debt to be reduced uniformly over the financial life of the station. This is the method followed by Ontario Hydro. Sinking fund depreciation makes the total cost of annual payments of interest on and depreciation, approximately equal over the financial life of the station. This is similar to most household mortgages and a modified version of Sinking Fund depreciation is the method chosen for capital repayment at Point Lepreau. The annual interest and depreciation cost is approximately $120 million.

3.2 Capital Modifications Made During Plant Life

Historically during the life of a CANDU, it is usual to make various modifications to the station design for a number of reasons as:

a) To meet the design intent and/or to improve station performance. These modifications are normally decided based on the early operating history and may be made to overcome problems which have caused plant trips or to improve operating efficiency and reduce operating cost.

b) To improve maintainability and operability. These modifications include the addition of access ladders and platforms, cranes and hoists, communications equipment, welding outlets etc. They may also include the addition of operating devices such as motorised valves, or even the addition of a complete system such as a Condensate Polisher (used to remove impurities from Condensate in the turbine cycle).

c) To resolve licensing problems required by the Regulator.

d) To overcome equipment ageing problems.

Historically these modifications continue throughout the life of the CANDU and typically amount to $10 to $20 million per year for a single unit plant. These costs tend to be higher in the early life of the station due to "immaturity" of the design. As the operating life progresses, the modification costs mostly address licensing and ageing issues. Feedback on modifications from operating stations to AECL design could make a significant contribution to reducing OM&A costs (and early life capital modifications) for future plants.

The large (and expensive) modifications are normally denominated as "Capital" and are charged to the capital cost of the station; the minor modifications are usually absorbed into the operating and maintenance cost There may be years when the capital spending may be considerably higher; for example, for a large scale pressure tube or steam generator replacement.

The cost of these "capital " modifications to the plant design are added to the total of remaining capital cost and are repaid over the remaining financial life of the plant. As the remaining plant life shortens, these costs become more significant as they must be depreciated over a shorter period. However, they are offset by the fact that some of the capital has been repaid by the depreciation charged to the plant.

3.3 Fuel

The fuel used during operation is charged to the plant as a separate "fuel" charge. Fuel includes the nuclear fuel plus the fuel for the diesel engines (or gas turbines) for standby and emergency power. It also includes fuel for the plant heating boiler if plant heat is supplied with fossil fuel. Typically plant heating is supplied from steam generated by the reactor. However, during shutdowns at a single unit plant, steam is needed for plant heating and for various other services such as the heavy water upgrader. The fossil fuel costs are usually minor when compared with the costs of the nuclear fuel.

A charge is made for long term disposal of spent nuclear fuel. An estimate of the cost of final disposal of irradiated fuel has been made and the cost of shipping the fuel to the final disposal site and the disposal costs are included in the charge made for fuel.

As the final disposal site for Canadian nuclear spent fuel has not yet been built (and a site for it has not yet been chosen), the spent fuel must be stored on an interim basis until the various decisions leading to ultimate disposal have been made. The fuel is initially stored in water filled spent fuel bays and then, after a cooling time in water of about 7 years, is moved to dry storage in concrete canisters of various designs.

The cost of the water filled storage bay is part of the initial capital cost of the station. The concrete canisters are built as needed and are counted as "Capital Modifications made during Plant Life" and their cost is added to the plant capital cost.

The cost of fuel for Point Lepreau including spent fuel disposal costs is about $ 10 to $15 million per year; this depends on the cost of fuel and the capacity factor achieved by the station.

OM & A ELEMENTS

- General Manager Nuclear
- Labor & Benefits
- Travel & Living, in Province
- Travel & Living, out-of Province
- Vehicle Costs
- Contractor Services
- Office Equipment
- Regulatory
- Consulting
- Hired Services
- Materials
- Computer Services
- Communications
- Tools & Equipment
- Properties
- Other
- Insurance allocated

COST COMPONENTS OF ENERGY

- To establish the cost of power the costs are defined as follows:
  - Cash Cost = $\dfrac{\text{OM \& A}}{\text{Net electrical energy generated}}$ (cents/KwH)
  - Production unit energy = $\dfrac{\text{(OM \&A + fuel + UFMP)}}{\text{Net elect. engy. gen.}}$
  - Where UFMP = Used fuel management provisions

COST COMPONENTS OF ENERGY

- Total Unit Energy Cost equals:
  - $\frac{\text{(OM \& A + fuel + UFMP + DPI)}}{\text{net electrical energy generated}}$
  - where DPI = Depreciation of minor fixed assets
    + Depreciation of plant
    + Provisions
    + Interest on provisions
    + Interest on the plant