

**CURRENT EXPERIENCE IN SUPPORTING COMMERCIAL
NUCLEAR POWER PLANT MAINTENANCE**

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BACKGROUND

The Nuclear Maintenance Applications Center (NMAC), Charlotte, North Carolina, is operated by the Electric Power Research Institute (EPRI), Palo Alto, California. NMAC was organized by EPRI in 1988, in response to member utility requests for specific assistance with performance improvement and cost control in the area of nuclear powerplant maintenance. The NMAC mission was to work with member utilities to identify both ongoing and emergent maintenance issues within the industry, and to distill industry experience from both the plants and the vendor community in successfully addressing these issues into practical, proven maintenance guidance for subsequent dissemination to member utilities. NMAC continues to focus on fulfilling this mission on behalf of its membership, and has expanded its services to include not only the preparation of topical maintenance guides, but also informative newsletters, technical notes, and hands-on workshops, as well as an annual international maintenance conference.

This intent of this paper is to provide staff from CANDU utilities who are members of NMAC with general information on the means by which NMAC functions in providing technical support, and to identify current industry maintenance issues of interest to NMAC members and the related NMAC activities which address those issues. Non-NMAC member utility representatives may also find the latter information on current maintenance issues to be of interest.

ANNUAL ISSUES REVIEW PROCESS

The principal effort in support of the NMAC mission is the annual issues review process. This process, which continues to be refined each year, enables NMAC to both understand and anticipate the near-term maintenance issue support requirements of its

member utilities; thereby improving NMAC's ability to be responsive in providing valuable and timely information that member utilities can utilize to improve their existing maintenance practices, reduce associated costs, or both.

Throughout each year, NMAC staff constantly accumulate various bits of information about the ongoing or emergent maintenance issues of interest to plant personnel at its member utilities. To accomplish this task, NMAC gathers information from a variety of sources. Principally, NMAC staff interact directly with working level plant staff from each of its member utilities' powerplants. This interaction can take place during the course of site visits to each powerplant site, where NMAC not only provides a status briefing on current and planned NMAC activities, but also solicits responses from plant staff on problems or maintenance issues of particular interest to them. NMAC staff solicit similar input from plant personnel attending topical workshops hosted by NMAC during the course of each year, as well as from attendees of the NMAC Annual Plant Maintenance Conference.

NMAC also monitors a number of industry information database relating to powerplant maintenance. These include the Nuclear Plant Reliability Database System (NPRDS) and Nuclear Network (NN) electronic bulletin board system, both operated by the Institute for Nuclear Power Operations (INPO), Atlanta, Georgia, and the OPEC-3 database maintained by the RCG/Haigler-Bally group, Denver, Colorado. NMAC also coordinates and shares information with technical personnel from both the Nuclear Energy Institute (NEI), Washington, D.C., and INPO. Recently, NMAC has also begun to coordinate with the World Association of Nuclear Operations (WANO), a sister-organization to INPO, also located in Atlanta, Georgia.

Another key element upon which NMAC relies to

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gather industry information is its NMAC Site Coordinator program. Under this program, NMAC has established a technical point-of-contact within the engineering and maintenance departments at each of its domestic member utility sites, and in the central maintenance and engineering organizations at each of its international member utilities. In some cases, where a utility desires to be a particularly active member, NMAC will also work with the utility to establish Coordinators in both its central office organization and its plant sites. These Coordinators provide an important communications link between NMAC and its members, disseminating information on NMAC products and services throughout the site, as well as routing requests for technical input to NMAC to the appropriate individuals at each site.

Each August, NMAC begins to compile all of the information gathered throughout the year into its annual issues survey. This survey is distributed to all NMAC Site Coordinators at member utility plant sites. The issues survey asks recipients to rank the issues identified during the past year in terms of how important that particular issue is to them in performance of their individual job, to their plant or utility, and to the industry as a whole.

Recipients are asked to fax their responses to NMAC no later than September 1st, after which NMAC compiles the responses into a ranked list and applies the first of two sets of filters to the list. The first filter is to prioritize the ranked listing. To do so, NMAC first considers the safety significance of the item relative to the other items on the list. NMAC then looks at each item relative to its potential to detract from the plants' overall capacity factor in the previous year, and its relative potential impact on plant maintenance budgets. Subsequently, NMAC applies the second filter to assure that the scope of the effort is appropriate for NMAC to address. The criteria for this filter are that each item must be of a generic technical nature to the industry as a whole. Each item must be a new issue and not one previously or concurrently being addressed by NMAC or others. It must be of a proper scale, that is, it must be capable of being addressed within the nominal one-year production cycle that is associated with most NMAC products. Finally, it is desirable that some synergy exists with respect to other ongoing or planned NMAC activities.

From these efforts, a final ranked and prioritized list of prospective projects are developed for presentation to utility members of the NMAC Steering Committee. The Committee meets each October to consider the NMAC budget for the coming calendar

year, as well as the proposed workscopes developed from the recently completed annual issues review. These issues, along with cost estimates for their completion, are considered and approved with respect to the budget.

Subsequently, NMAC enters into a "scoping phase" in which a technical advisory group (TAG) for each project is formed. Each TAG is comprised of knowledgeable technical staff volunteers from member utilities, as well as other industry experts in the topical area. The TAG assists NMAC in determining both the proper scope and focus of each new maintenance guide, as well as indicating specific information that each guide should include. With TAG input, NMAC then embarks upon the preparation process which may take anywhere from 6-9 months to complete. During this time, the TAG continues to serve as a draft review committee, providing important guidance with respect to the organization and technical content of each NMAC product. Upon completing the draft preparation process, final comments from the TAG are incorporated into the final draft report, which is then sent to the NMAC publications group for final layout and printing. NMAC final reports are then delivered to the NMAC Coordinators at member utilities for subsequent distribution within their utilities; all usually within the one-year production timeframe from inception to distribution.

NMAC usually follows up each newly distributed product with a "hands-on" technical workshop. The workshop is based upon the premise that each new NMAC product represents a "distillation of practical, proven industry experience" for improved power-plant maintenance. Therefore, the purpose of each NMAC workshop is to assist utilities in speeding implementation of this "distilled...experience" into its own maintenance practices and procedures by providing actual hands-on training to those plant personnel responsible for maintenance of the specific component or system covered by the NMAC guide.

NMAC PRODUCTS

Over the years, NMAC has published more than fifty (50) topical maintenance guides on a variety of subjects. An example of a new NMAC guide providing both useful and timely information is in the area of small steam turbine maintenance used for auxiliary feedwater (AFW), high-pressure coolant injection (HPCI) and reactor core isolation cooling (RCIC) applications, as in the Terry® Turbine Maintenance and Troubleshooting Guide. Recent USNRC attention has become focused on this system, significantly elevating its operations and maintenance importance to

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member utilities. Another recent example of a particularly useful guide providing access to otherwise unavailable information would be for the management and prevention of primary system borated-water leakage in PWR powerplants, as in the Boric Acid Corrosion Guidebook. Despite industry responses to USNRC Generic Letter 88-05, requiring implementation of a management plan for dealing with instances of primary system borated water leakage and corrosion, most operators of PWR powerplants continue to struggle with these problems. Likewise, NMAC continues to produce guides which meet immediate member needs.

With the participation of its international members, NMAC has recently begun translating selected guides into other languages. To date, NMAC has published a number of guides in either French or Spanish, and hopes to expand this translation program in coming years with the continued cooperation of its international membership.

While NMAC is perhaps best known for its principal product, NMAC maintenance guides, NMAC has developed a variety of products. These products also include topical workshops, technical notes, and newsletters. Technical notes, or "Tech Notes" as they are titled, represent an important new addition to the list of NMAC products and services. While NMAC maintenance guides usually present information on specific components or systems, Tech Notes are aimed more at providing utility members with information and solutions to emergent issues. Examples of recent Tech Note titles include "Field Testing of Overcurrent Trip Units for Low Voltage Circuit Breakers (LVCD) Used in DC Applications", "Introduction to Nuclear Plant Steam Turbine Control Systems" and "Winterizing Diesel Fuel Oil".

As previously described, NMAC topical workshops usually occur as follow-on activities associated with NMAC guides. In addition, NMAC repeats selected popular workshops periodically, such as Lubrication, Terry Turbine maintenance, and Electric Motor maintenance. This year, in response to member requests for improved guidance and assistance in reducing leakage from bolted piping joints, NMAC developed a completely new Plant Leak Reduction Workshop which it conducts onsite upon request at member powerplants. To date, more than 100 personnel from two member plants have completed the one-day course, with several additional plants now working to schedule future workshops at their sites. Recognizing that both plant management and operations personnel have important responsibilities which contribute to an effective plant leak reduction

program, the workshop commences with a 3-hour management session, followed by a series of 1-day technical sessions. Each management session is presented to selected site maintenance and engineering personnel, as well as representatives of work planning, quality assurance and other appropriate department representatives as determined by each site's workshop sponsor. The management session presents highlights of the technical session content, but focuses upon those specific actions which management must take to improve its present plant leak reduction program. The hands-on technical sessions can each accommodate up to fifteen (15) personnel, and represent a mix of traditional classroom instruction and hands-on training using custom designed equipment. This equipment enables participants to not only measure the relative effectiveness of various lubricants in use at their individual site, but also the importance and relative effectiveness of different lubricant application techniques. The equipment also allows participants to compare the effectiveness of different bolting techniques, graphically illustrating not only the actual relationship between applied torque and resultant preload, but also the effects of gasket creep, flange rotation and elastic interaction within the bolt circle. Even the most critical mechanics have indicated that they found significant value in the material and presentations during the workshop, particularly with respect to proper lubricant application techniques, use of hardened steel washers, and the relative effectiveness of various bolt tensioning methods.

NMAC also publishes two newsletters, the *NMAC Memo* and *Lube Notes*, which it distributes periodically to members throughout the year. The *NMAC Memo* is published quarterly, and presents updated information on NMAC activities, as well as timely articles addressing current maintenance issues. For example, diesel engine maintenance continues to rank as a significant issue. To keep abreast of diesel issues and maintenance, NMAC participates in various diesel owners group meetings. Through this type of ongoing participation, NMAC perceived earlier this year that use of diesel engine analysis is on the increase. Diesel engine analysis is a non-intrusive process of gathering engine pressure, vibration, and ultrasonic data and evaluating it to assess the engine's performance and mechanical condition. In addition, NMAC found that many utility personnel were unfamiliar with this technology and had questions regarding both the technology and the implications of its use. To address these issues, NMAC published a detailed article on this topic in its most recent *NMAC Memo*. The article provides insight

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into the technology itself, questions regarding its use, and the viewpoint from the USNRC as it relates to this technology. The article also discusses the possibility of using this technology to eventually decrease intrusive maintenance and its associated maintenance cost.

Lube Notes, the other NMAC newsletter, is published semi-annually. Its easy, question-and-answer format provides readers with information on solutions to actual plant issues posed by NMAC-member utility staff. *Lube Notes* is edited by a noted expert in the area of lubricants and lubrication. This expert, Dr. Bob Bolt, is retained by NMAC to answer questions in the topical area, at no charge to member utilities. It is the results of this service that are compiled into subsequent issues of *Lube Notes*, for dissemination to all NMAC-member utilities.

EMERGENT MAINTENANCE ISSUES

As previously mentioned, having recently completed the annual issues review process for 1995-96, the following information characterizes the top plant maintenance issues in descending order. The priority of these issues, as compared with the results of the 1994-95 annual NMAC issues review, illustrates the changing focus of significant concerns to the industry and new opportunities for NMAC to be of continued service to its membership.

Valve Maintenance. Valve maintenance rose from the number 3 issue last year to the number 1 position this year. Preliminary indications are that valve packing installation, maintenance leading to proper safety relief valve operation, and maintenance to reduce seat and bonnet leakage represent the primary scope for subsequent maintenance guide. NMAC is responding by updating an existing EPRI report, *NP-6516, Guide for the Application and Use of Valves*, to address these areas. The resulting NMAC guide should be available later in 1996.

Predictive Maintenance. Over the last year, predictive maintenance has risen from number 13 on the issues survey to number 2 this year. Preliminary indications are that utilities are becoming more concerned with the need to sustain the quality of future maintenance activities with reduced resources. Hence the desire to optimize plant maintenance activities through the application of proven predictive maintenance technologies. NMAC is encouraging utilities to begin by developing sound vibration, oil analysis, and infrared thermography programs as the basis for their suite of predictive tools, beginning with its report *NP-6973R2, Infrared Thermography*

Guide. NMAC is also working on developing new condition monitoring information for use as a basis for determining the most cost-effective application of these technologies. This new report will be available later in 1996. Subsequent work in the area of predictive technologies will be addressed on an as-needed basis through the publication of individual NMAC Tech Notes in each topical area.

Instrumentation & Control. General I&C issues have risen from the number 11 position last year to the number 3 position this year. Preliminary indications are that a wide variety of I&C issues are responsible for increased attention in the area, including reliability of power supplies, radiation monitoring equipment, turbine controls, feedwater controls, and relays. Also of interest are digital I&C upgrades and optimization of calibration and surveillance frequencies. Presently, NMAC is presently preparing a Feedwater I&C Maintenance Guide, a Radiation Monitoring Maintenance Guide, and a Turbine Control System Hydraulic Components Guide. Subsequent work planned includes a Turbine Control System Electronic Components Guide, a Power Supply Tech Note, and a Capacitors Tech Note. NMAC is also following ongoing EPRI work in the areas of digital I&C upgrades, and I&C calibration and surveillance frequencies, and will incorporate maintenance information in our guides as appropriate.

Pumps. General pump issues remain at the number 4 position in both the 1994-95 and 95-96 issues surveys. Preliminary indications are that dynamic seals, hydraulic issues, and proper maintenance of feedwater-, reactor coolant- and charging-type pumps are the areas requiring increased maintenance attention this year. NMAC is planning a Tech Note to address a variety of dynamic seals, including mechanical seals used in pumps for 1996 delivery. In addition to the recently completed report *TR-100855, Main Coolant Pump Seal Maintenance and Troubleshooting Guide*, NMAC is presently developing feedwater pump and charging pump guides to address issues specific to those pump types.

Air-Operated Valves. Due possibly to the conclusion of the industry's attention to the USNRC Generic Letter 89-10, addressing maintenance requirements for motor-operated valves, industry attention now seems to be turning to preparations to proactively address AOV maintenance in a similar manner. This increased attention has raised AOV issues from the number 9 position last year, to the number 5 position this year. Industry interest seems to be centering on increasing diagnostic capabilities for plant maintenance staff, minimization of stem

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leakages, and predictive maintenance for elastomeric diaphragms. NMAC is presently revising its report *NP-7412, Air-Operated Valve Maintenance Guide*, to incorporate updated AOV diagnostic information, expanded information on proper valve packing techniques, and a section on degradation of elastomeric compounds, specifically diaphragms. The revision should be available in mid-1996.

Emergency Diesel Generators. Emergency diesel generator maintenance remains a significant plant maintenance issue, dropping only slightly from its number 5 position in 1994-95, to number 6 position this year. Preliminary indications are that accelerated aging degradation resulting from increased testing requirements may be a major contributing factor to its continuance as an important plant maintenance issue. NMAC is presently preparing both a diesel engine analysis guide and a diesel generator bearing analysis tech note for distribution later this year. NMAC is also planning to present a comprehensive Diesel Engine Analysis workshop for NMAC-member utilities in Orlando, Florida this December.

Motor-Operated Valves. Industry interest in motor-operated valve maintenance has remained at the number 7 position. It appears that plant staff are primarily interested in information resulting from EPRI's Motor-Operated Valve Performance Prediction Program (MOV/PPP) in the area of proper stem/stem nut lubrication. NMAC is working with the MOV/PPP team to extract pertinent data in this interest area from the program information and revise its report *NP-6660, Application Guide for Motor-Operated Valves*, to include such information. The revision is planned for release in mid-1996.

Motors. Increasing industry interest in electric motors, particularly with respect to medium-to-large electrical motors such as for feedwater or reactor coolant pumps, has elevated electric motor issues from number 14 last year to the number 8 position this year. Preliminary indications are that aging-related degradation may be the root cause for many of the reported concerns. In response to this significant

increase, NMAC is preparing to revise its existing report *NP-7502, Electric Motor Predictive and Preventive Maintenance Guide*, using information from EPRI ongoing projects on electric motor predictive maintenance and mild and harsh environment specifications for motor rewinding, and from other industry sources to address this issue.

Safety Relief Valves. Safety relief valves (SRVs) did not appear on the past issues review, but jumped to the number 9 position in this year's analysis. No explanation is immediately apparent for this sudden increase in interest. Preliminary indications are that the principal maintenance issues associated with SRVs are set point drift and proper in-house calibration techniques. NMAC is in the process of preparing a maintenance guide targeted at SRVs and specifically addressing these areas of interest. The guide should be available in mid-1996.

CONCLUSION

As you can observe, over the years NMAC has developed a refined methodology for identifying and responding to the emergent plant maintenance issues of its member utilities. Current activities as they relate to the results of the most recently completed annual issues review indicate that in most instances, NMAC either remains ahead of the curve in developing needed technical information to address member issues, or has been able to initiate required technical activities in rapid fashion. For utility-specific concerns which do not address generic industry issues, NMAC has also been successful in arranging co-funded technical activities to meet member needs on a more individualized basis. Finally, NMAC is looking forward a new ways of providing increased value to its members, through electronic document delivery, Internet/World Wide Web connectivity, and perhaps through future development of individual Offshore Maintenance Centers to better support NMAC's growing list of international member utilities.

