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Research

Safety-Related Contractor Activities at Nuclear Power Plants

New Challenges for Regulatory Oversight

Alan Chockie

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SKI

SKI Perspective

Background

In recent years, there have been a number of initiatives to reduce operating expenses and make operations at nuclear power plants more efficient. One result of these optimization initiatives often is the increased use of contractors and the outsourcing of certain tasks and activities. Although the use of contractors and outsourcing has been a common practice in the nuclear industry worldwide, the nature and the amount of contractor use has changed substantially in recent years. These changes are driven by such factors as new partnering, alliances, the use of foreign companies, the loss of technical competence by many vendor organizations, and the disappearance of nuclear equipment suppliers and their experience and knowledge of the design features of the equipment.

The increasing level of concern with the safety implications of these changes can be seen in the growing body of regulatory and utility meetings and workshops on the subject of contracting.

Based on these concerns, SKI started a research project to identify the safety challenges and implications of the industry's use of and the safety management of contractors.

SKI´s Purpose

The objective of the project is to assist SKI in the development of guidance for the regulatory analysis of safety management of contracting at Swedish nuclear power plants. There are two steps in the development of the regulatory guidance. This report describes the results of first step i.e., to identify the positive and negative safety implications of contracting activities – both at nuclear power plants and at other relevant industries.

Results

The review of the positive and negative safety implications of contracting activities has resulted in an overview of the existing weaknesses in the implementation of the contract management process, and has identified future regulatory and industry safety challenges affecting the safety management of contractors such as

- the aging of the workforce
- the decline of the nuclear industry
- deregulation of nuclear power.

Another result is a proposal of a general model of a regulatory guidance.

Continued Works

The next step in the project is to further develop the proposed regulatory guide on the safety management of contractors.

Effects on SKI´s Work

The review of the positive and negative safety implications of contracting activities has resulted in a deeper knowledge of the safety issues in this area, and a knowledge base for the development of a regulatory guide.

Project Information

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SKI Identification Number: 14.3-040247

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Sammanfattning

Användningen av entreprenörer/leverantörer har sedan kärnkraftverkens tillkomst varit en integrerad och viktig del vid design, konstruktion, drift och underhåll. Tillståndshavarna för kärnkraftverken i Sverige och i omvärlden har successivt utvecklat och förfinat sina processer för upphandling, styrning, övervakning och uppföljning av entreprenörer för att försäkra sig om att entreprenörerna utför sina arbetsuppgifter på ett säkert och effektivt sätt. Fastän dessa ledningsprocesser avseende entreprenörer har visat sig vara effektiva verktyg för upphandling av stöd och komponenter anpassade till kärnkraftverkens behov, har det inträffat händelser och olyckor i omvärlden relaterade till användning av entreprenörer. Dessa händelser och olyckor har visat på brister i införandet av dessa ledningsprocesser.

Att identifiera och ta hand om de problem som finns och som berör införandet av ledningsprocesser för entreprenörer har blivit alltmer komplicerat beroende på organisatoriska och personella förändringar inom kärnkraftsindustrin. Myndigheters och tillståndshavares förmåga att effektivt övervaka och hantera säkerhetsfrågor relaterade till användningen av entreprenörer kommer troligtvis att påverkas av kommande organisations- och personalförändringar beroende på:

- en åldrande arbetskraft
- en nedgång inom den nukleära industrin
- avregleringen av elmarknaden.

Syftet med denna rapport är att ge en översikt över aktuella och möjliga framtida utmaningar avseende de säkerhetsrelaterade aktiviteter som berör användningen av entreprenörer inom kärnkraftbranschen. Syftet är också att ge stöd till SKI i att etablera en tillsynsstrategi (tillsynsvägledning) med ett förebyggande förhållningssätt i dessa frågor.

Ledningsprocessen för entreprenörer – identifierade problem som berör införandet av ledningsprocessen

Ledningsprocesser för entreprenörer är framtagna med syfte att ge stöd till individer och organisationer vid utveckling och bibehållande av ett förebyggande och säkerhetsmedvetet angreppssätt avseende det arbete som utförs av entreprenörer. Guider om säkerhet och kvalitetsledning ger dessutom en grund för att försäkra sig om att personalen får tillräcklig kunskap, verktyg, materiel, information samt att arbetet samordnas för att kunna utföras på ett säkert och effektivt sätt.

Som nämnts inledningsvis har tillståndshavarna med åren vidareutvecklat dessa ledningsprocesser så att de ska leva upp till kraven på anläggningarna. Olyckor och händelser vid kärntekniska anläggningar som berör leverantörer har dock uppdagat flera viktiga svagheter i införandet av ledningsprocessen. Det stora bekymret är dock generellt inte frånvaron av instruktioner eller dokumenterade krav, utan brist på ett effektivt införande av dessa processer.

Den vanligaste förekommande bidragande faktorn till dessa händelser är tillståndshavarnas brist på övervakning av det arbete som utförs av leverantörer. Förändringar i design identifierades också såsom en vanligt bidragande orsak. Förändringarna i sig var emellertid

vanligtvis inte problemet, utan problemet var ofta misslyckandet hos leverantörer och tillståndshavare att uppmärksamma säkerhetsbetydelsen av dessa förändringar och att informera andra om förändringarna, samt att följa ledningssystemets instruktioner.

En annan bidragande faktor till ett flertal nyligen inträffade händelser relaterade till leverantörer är ett felaktigt antagande om leverantörers färdigheter och kunskaper. Sådana antaganden har lett till otillräcklig och ineffektiv utbildning av leverantörer och underleverantörer.

När man går igenom entreprenörsrelaterade händelser och olyckor framträder två underliggande frågeställningar:

- bristen på ett kontinuerligt säkerhetsmedvetande hos entreprenörer och tillståndshavare – människor misslyckas då och då med att se säkerhetskonsekvenser av sina handlingar eller möjliga risker genom att ej uppmärksamma förändringar beroende på orsaker såsom begränsad erfarenhet, otillräcklig information, trötthet, överdriven bekantskap med uppgifterna och självbelåtenhet, eller bristfällig vägledning och övervakning
- bristen på effektiv kommunikation – det finns ofta varken formella eller informella kommunikationskanaler för att försäkra sig om att säkerhetsrelaterad information ges till den personal som berörs på ett tidsmässigt och effektivt sätt. Tilläggas kan att entreprenörer sällan får ekonomiska fördelar eller uppmuntran för att dokumentera och rapportera upptäckta säkerhetsrisker eller observationer.

Nära förestående säkerhetsrelaterade utmaningar

Det finns ett antal förändringar som förväntas ske inom en nära framtid avseende organisation och personal vilka har en betydande påverkan på tillståndshavarnas förmåga att effektivt övervaka och leda arbeten som utförs av entreprenörer.

En åldrande arbetskraft: många industriarbetare börjar närma sig sin pensionsålder. Farhågan är att plötsligt förlora en stor andel av den mest erfarna och kunniga personalen inom samtliga verksamhetsområden hos tillståndshavare, entreprenörer och säkerhetsmyndigheter. Samtidigt som det kan finnas ett utökat behov av att övervaka och följa entreprenörsarbeten hos tillståndshavarna, kommer den personal hos tillståndshavarna som är mest erfaren och kunnig i dessa processer att också gå i pension.

Åldrandet i sig medför att både den mentala och den fysiska förmågan tenderar att avta. Farhågan är att denna försämring kan påverka de uppgifter som läggs ut på entreprenörer, eftersom dessa uppgifter vanligtvis ställer höga krav på minne, syn, rörlighet, styrka, beslutsfattande, samt reaktionsförmåga.

Nedgången inom den nukleära industrin: den faktiska eller upplevda nedgången inom den nukleära industrin inom många länder har lett till en påtaglig nedgång i antalet människor som börjar arbeta inom det nukleära området eller relaterad forskning, samt en brist på kvalificerad personal som kan ersätta pensionsavgångarna. Även tjänster som har en mer stödjande karaktär blir troligtvis svåra att ersätta.

Bristen på entreprenörer, säljare och tillverkare inom den nukleära marknaden har funnits under flera år och fortsätter att skapa problem för tillståndshavarna när de behöver byta ut delar i säkerhetssystem och samtidigt se till att de uppfyller kraven på säkerhet och kvalitet. Flera företag som var med i utvecklingen av de kärntekniska anläggningarna finns inte längre och de som fortfarande finns kvar har upplevt stora organisatoriska förändringar. Dessa förändringar har lett till farhågor om: att en enhetlig säkerhetskultur kan vara svår att uppnå eller bibehålla; att det kan finnas brister avseende organisatoriskt minne och teknisk information eftersom personalen nu är integrerad i nya organisationer; att ett reducerat antal tillgängliga leverantörer kan leda till problem; samt att det kan finnas svårigheter i att tillförsäkra långsiktiga överenskommelser/kontrakt med entreprenörer.

Avreglering av elmarknaden: avregleringen av elmarknaden under senare år har resulterat i ett antal initiativ från tillståndshavarnas sida för att minska kostnader och att effektivisera driften.

Ett sådant initiativ är att i större utsträckning än tidigare lägga ut säkerhetsrelaterade uppgifter/verksamheter såsom underhåll, upphandling och hälsoundersökningar på leverantörer. Att lägga ut verksamhet s.k. ”outsourcing” har visat sig ekonomiskt gynnsamt i många fall, men det har också visat sig att det inte är så lätt att ta tillbaka uppgifterna till organisationen när de väl har lagts ut. En nyckel till en effektiv outsourcing är att entreprenörerna är integrerade i tillståndshavarnas säkerhetskultur och en tydlig definition och kommunikation om målen med arbetsuppgifterna både för entreprenörernas och för tillståndshavarnas personal.

En farhåga i detta sammanhang är om den personal som är kvar hos tillståndshavarna, efter en minskning av personal beroende på pensionering eller kostnadsbesparingar, har tillräckliga kunskaper inom teknik och ledarskap för att planera, samordna och övervaka/följa upp det arbete som blivit utlagt på entreprenörer.

Sammanslagningar av organisationer eller förvärvande av bolag inom den nukleära branschen, som en effekt av avregleringen av elmarknaden, har skapat svårigheter när det gäller integreringen av personal från entreprenörer och tillståndshavare i de nya organisationernas säkerhetskultur (dvs. i de uppfattningar, delade värden och beteenden som avspeglas i beslutfattandet och i utförandet av arbetsuppgifter). Från ett myndighetsperspektiv kan detta innebära svårigheter i att förstå och bedöma effektiviteten i den förändrade säkerhetskulturen.

Förändringar i ansvar och roller hos entreprenörer och tillståndshavare

Med utgångspunkt från lärdomarna från tidigare entreprenörsrelaterade händelser och olyckor samt de nära förestående utmaningarna för industrin, behöver entreprenörer och tillståndshavare anta nya roller och nytt ansvar. Det yttersta ansvaret för säkerheten är dock alltid tillståndshavarens. Entreprenörerna behöver t.ex. ha ett mer strukturerat och formellt tillvägagångssätt för att värdera/bedöma arbetet från både en ekonomisk och en säkerhetsmässig utgångspunkt. Tidigare genomfördra riskvärderingar av projekt eller arbeten som utförs av leverantörer har vanligtvis genomförts på ett informellt sätt. Det tas nu emellertid initiativ inom industrin till att etablera en mer formell riskvärderingsprocess.

Alla entreprenörsaktiviteter och uppgifter innehåller inte samma säkerhetsrisker. Tillståndshavaren är ansvarig för den inledande riskvärderingen av de föreslagna arbetsuppgifterna för anläggning och personal. Entreprenören har ansvar för att arbeta tillsammans med tillståndshavaren för att förbättra den inledande riskbedömningen och att genomföra nödvändiga förändringar i arbetsmetoderna, materiel eller arbetssekvenser tillräckligt tidigt för att undvika eller reducera risker för personskador eller skador på utrustning.

Fördelarna med formella riskvärderingar är t.ex. att:

- dokumenterade resultat från riskvärderingar och bakgrunden till dessa kan ge ett bättre stöd till både tillståndshavaren och myndigheter i deras bedömning av omfattningen i tillsynen beroende på projektens/arbetsuppgifternas säkerhetsbetydelse
- dessa kan användas för att informera all personal eller parter som är berörda – eftersom alltfler av den erfarna personalen hos entreprenörer, tillståndshavare och myndigheter pensioneras inom de närmaste åren blir en sådan dokumentation och kommunikation ännu mer viktig för att undvika problem och minimera säkerhetsrisker förknippade med arbetsuppgifter som utförs av entreprenörer
- riskvärdering kan användas som ett stöd i kommunikationen med säkerhetsmyndigheterna.

Tillståndshavaren behöver inom den närmsta framtiden bli mer av en ”intelligent kund” (”intelligent customer”) dvs. ha tillräcklig kompetens för att beställa, leda och styra, följa upp och utvärdera det arbete som läggs ut på leverantörer. Tillståndshavaren behöver kunna bedöma behovet av teknisk kompetens och kompetens att leda arbetet för att kunna avgöra säkerhetskonsekvenserna av förslagna arbeten och för att effektivt kunna övervaka leverantörernas arbetsuppgifter. Det finns risk för att tillståndshavaren oavsiktligt delegerar ansvaret för säkerheten till leverantören om man inte har tillräcklig kompetens att bedöma säkerhetsbetydelsen av föreslagna uppgifter. Denna risk kan komma att förstärkas i samband med att erfaren och kompetent personal pensioneras.

En annan fråga, som tidigare nämnts och som tillståndshavarna ställs inför, är att försäkra sig om att personalen från entreprenörer integreras i säkerhetskulturen vid anläggningen. Entreprenörer som anlitas behöver betraktas som en integrerad del i tillståndshavarens organisation och arbeta enligt samma säkerhets- och kvalitetskrav som den egna personalen.

Att ha en ständigt pågående kommunikation mellan tillståndshavare och entreprenör kommer att bli alltmer viktigt under de kommande åren. Under hela den tid som entreprenören utför arbeten behöver de inkluderas i samtliga relevanta säkerhetsgranskningsmöten och kommunikation. Dessutom kommer omfattningen av övervakning av entreprenörernas arbeten att bero på faktorer såsom den typ av arbeten som utförs och den specifika erfarenhet som personalen har för uppgiften och inte enbart erfarenheten hos entreprenörsföretaget som helhet.

Nya tillsynsutmaningar

En viktig utmaning för myndighetstillsynen är att försäkra sig om att tillståndshavarna arbetar förebyggande och att de uppfattar förändringarna i omvärlden när det gäller entreprenörer och

dessa förändringars konsekvenser för säkerheten. Myndigheterna behöver försäkra sig om att strategier och instruktioner finns utvecklade när de behövs för att undvika eller minimera risker relaterade till användningen av leverantörer i arbetet och för att försäkra sig om en fortsatt säker och effektiv drift av anläggningarna.

Säkerhetsmyndigheter behöver försäkra sig om att tillståndshavarna arbetar för att förbättra:

- stegen i planeringen i ledningsprocessen för leverantörer
    - försäkra sig om att tillståndshavarna är en intelligent kund (”Intelligent customer”) dvs. ha tillräcklig kompetens för att beställa, leda och styra, följa upp och utvärdera det arbete som läggs ut på leverantörer
    - integreringen av entreprenörer i tillståndshavarens säkerhetskultur
    - genomförandet av formella riskvärderingar av de arbeten eller projekt som ska utföras av entreprenörer
- effektiviteten i kommunikationen mellan samtliga parter/berörda och över hela arbetsprocessen
- nivån i säkerhetsmedvetandet hos både tillståndshavare och entreprenörspersonal som anlitas.

Myndigheterna behöver också bevaka hur åldrandet hos arbetskraften och svårigheterna att få tag i kvalificerad personal kan påverka deras egen förmåga att utöva tillsyn inom området.

Myndigheter, tillståndshavare och entreprenörer behöver samtliga:

- vara medvetna om den nuvarande och framtida situationen när det gäller de förändringar som sker hos entreprenörer och deras kompetens och organisationer
- förstå säkerhetskonsekvenserna av dessa förändringar
- påbörja förebyggande åtgärder
- fortsätta att förbättra sina processer såsom situationen kräver
- hålla jämna steg med de aktiviteter/åtgärdsprogram som andra utvecklar och som kan ge stöd i den egna utvecklingen.

Med utgångspunkt från innehållet i denna rapport avser SKI att utveckla en tillsynsvägledning för tillsynen av tillståndshavarnas egenkontroll när det gäller upphandling, ledning och styrning samt uppföljning och utvärdering av leverantörer. Rapporten innehåller en generell modell för de nödvändiga steg som behöver finnas i en ledningsprocess för upphandling och ledning och styrning av entreprenörer. Denna modell är en utgångspunkt för framtagningen av tillsynsvägledning inom området.

Summary

The use of contractors has been an integral and important part of the design, construction, operation, and maintenance of nuclear power plants. To ensure the safe and efficient completion of contracted tasks, each nuclear plant licensee has developed and refined formal contract management processes to meet their specific needs and plant requirements. Although these contract management processes have proven to be effective tools for the procurement of support and components tailored to the needs of nuclear power plants, contractor-related incidents and accidents have revealed some serious weaknesses with the *implementation* of these processes.

Identifying and addressing implementation problems are becoming more complicated due to organizational and personnel changes affecting the nuclear power industry. The ability of regulators and licensees to effectively monitor and manage the safety-related performance of contractors will likely be affected by forthcoming organization and personnel changes due to:

- the aging of the workforce
- the decline of the nuclear industry
- the deregulation of nuclear power

The objective of this report is to provide a review of current and potential future challenges facing safety-related contractor activities at nuclear power plants. The purpose is to assist the Swedish Nuclear Power Inspectorate (SKI) in establishing a strategy for the proactive oversight of contractor safety-related activities at Swedish nuclear power plants and facilities.

The Contract Management Process – Past Implementation Problems

Contract management processes are designed to assist individuals and organizations develop and maintain a proactive safety awareness approach to the contracted work. The safety and quality management guidelines provide a foundation upon which the personnel are provided the appropriate knowledge, tools, material, information, and coordination to be able to perform the work in a safe and efficient manner.

Over the years the licensees have refined these processes to meet their specific needs and plant requirements. The primary fault of the contract management process is generally not the absence of procedures or documented requirements, but rather the lack of effective implementation. Accidents and incidents at nuclear power plants involving contractor actions revealed several key weaknesses with the implementation of contract management processes.

The most common contributing factor was the lack of supervision of the contracted work by the licensee. Design changes were also identified as a common contributing cause. However, the changes themselves were usually not the problem. Rather the problem was often the failure of the contractor and licensee personnel to recognize the potential safety significance of the changes, to inform others of the changes, and to follow quality assurance procedures.

Another contributing factor in a number of recent contractor-related events has been incorrect assumptions about a person's skills and knowledge. Such assumptions have lead to insufficient or ineffective training of the licensee, contractor, and subcontractor personnel.

In reviewing contractor related incidents and accidents there appears to be two fundamental underlying issues:

- the lack of continuous safety awareness by contractor and licensee personnel – people periodically fail to notice the safety implications of their actions or potential hazards from unanticipated changes due to such reasons as limited experience, poor information, fatigue, excessive task familiarity and complacency, or inadequate guidance and supervision
- the lack of effective communication – there are often neither formal nor informal communication channels to ensure that safety-related information is provided to all appropriate individuals in a timely and efficient manner. In addition, contractors are seldom provided financial incentives to document and report safety concerns and observations.

Impending Safety-Related Challenges

There are a number of organizational and personnel changes that are expected in the near future to have significant impacts on the ability to effectively monitor and mange the safety-related performance of contractors.

Aging of the Workforce: Many of those working in the industry are beginning to reach retirement age. The concern is the sudden loss of a majority of the most experienced, skilled, and knowledgeable staff from all areas of the licensee, contractor, and regulatory organizations. At the same time that additional licensee monitoring and supervision of the contractor work may be required, the licensee personnel that are the most familiar and experienced in monitoring the contract process and overseeing the contractor's work activities will be retiring as well.

As the individual worker ages their mental and physical capabilities tend to decline. The concern is that many of the contracted tasks place high demands on memory, vision, range-of-motion, strength, decision making, and reaction capabilities.

Decline of the Nuclear Industry: The actual or perceived decline of the nuclear industry in many countries has lead to a significant decline in the number of people entering nuclear field or related science and engineering programs and the lack of qualified skilled personnel to replace retiring staff. Also, many supporting job positions will likely be difficult to fill.

The loss of contractors, vendors, and manufacturers from the nuclear power market has been taking place for many years and continues to create problems for the licensees when they need to obtain "nuclear grade" replacement parts for safety systems. Many of the companies that were major actors in the development of the nuclear plants are no longer in existence and those that do exist have experienced major organizational changes. These have lead to concerns due to the loss of a consistent safety culture, the

loss of institutional memory and technical information as staff are integrated into new organizations, the reduced number of contractor resources available, and the difficulties of ensuring long term contracting arrangements.

Deregulation of Nuclear Power: The deregulation of nuclear power in recent years has resulted in a number of initiatives by licensees to reduce expenses and make operations more efficient.
One initiative is the possible increased outsourcing of safety related tasks or activities such as maintenance, procurement, and health physics. Although outsourcing has been shown to be economically beneficial in many cases, once outsourced few organizations desire, or are able, to take the work back in-house. A key to effective outsourcing is the integration of the contractor into the licensee's safety culture and the clear definition and communication of the work objectives to both contractor and licensee personnel.

A related concern is that with the reduction of licensee personnel due to retirement or cost cutting measures, the remaining licensee staff must have technical & managerial skills to properly plan, coordinate, and oversee the increased outsource work.

Deregulation related utility mergers and acquisitions have created difficulties in the integration of licensee staff and contractor personnel into the new organization's safety culture (i.e., the beliefs, shared values, and behaviors reflected in making decisions and performing work). From a regulatory perspective it has created potential difficulty in understanding and assessing the effectiveness of the changing safety culture.

Changing Responsibilities for Contractors and Licensees

Based on the lessons learned from past contractor-related incidents and accidents and the forthcoming challenges facing the industry, contractors and licensees will need to take on new or expanded roles and responsibilities. For example, contractors will need to take a much more structured and formal approach to assessing the nature of the work from both an economic and safety standpoint. Previously assessments of project risk have usually been done in an "informal" manner. However there are now initiatives to establish more "formal" risk assessment processes.

Not all contractor activities and tasks have the same potential safety implications. The licensee is responsible for the initial determination of the general level of plant and personnel risk associated with the proposed work tasks. The contractor has a responsibility to work with the licensee to refine the initial risk assessment and make any necessary changes in the work methodology, materials, or sequence early enough to avoid or reduce the risks of personnel injury or equipment damage.

Key benefits of formal assessments are obtained from the requirements to:

- document findings and the rationale behind them – the documentation will assist regulators to determine the appropriate level of oversight based on the level of project safety significance
- inform all relevant parties of the assessment results – as more experienced contractor, licensee, and regulatory staff retire in coming years, such documentation and communication will become even more important to avoid problems and minimize the safety risks associated with similar work

- use the assessment in establishing and communicating the scope and timing of the licensee's oversight of the contractor's work

Licensees can not delegate plant safety. Although a licensee can delegate authority to a contractor to perform tasks on its behalf, in no case can the licensee delegate its prime responsibility for plant safety. It is the responsibility of the licensee to ensure that the contractor meets all the relevant quality and safety standards.

In the coming years the licensee will need to be much more of an "intelligent customer". They will need to recognize the technical and managerial competence necessary to determine the safety implications of any proposed work and to effectively oversee the contracted work activities. Although it is preferable that the necessary competence reside within the licensee's organization, in certain situations this may not be possible and outside assistance and guidance will be required.

When licensees do not recognize their lack of competence or the safety significance of the proposed tasks, it is possible to inadvertently delegate the responsibility for the safety of the plant to the contractor. Properly addressing this issue will be even more critical as licensee and contractor organizations continue to consolidate and experienced personnel retire.

Another issue facing licensees will be to ensure contractor personnel are integrated into the plant safety culture. Contractors should be considered to be an integral part of the licensee's organization and work to the same safety and quality standards as would a licensee staff member. As more contractors consolidate and internationalize their operations, licensees will need to be more conscientious to recognize and address potential differences between the safety culture at the plant and the safety culture of the contractor.

Continuous communication between licensee and contractor will become even more critical in coming years. Throughout the work assignment, contractor personnel should be included in all relevant plant safety review meetings and communications. Also, the degree of oversight or direct supervision of the contractor's work by the licensee will depend on such factors as the type of work being performed and the specific experience and background of the contractor personnel and not just the experience of the contractor organization.

New Challenges for Regulatory Oversight

The key challenge for regulatory oversight of safety-related maintenance contractor activities is to ensure that licensees are being proactive and that they are recognizing and addressing the safety-related implications of the changing environment for contractor work. The regulator needs to be assured that strategies and procedures are being developed in a timely manner to avoid or minimize the risk associated with safety-related contractor work and to ensure the continued safe and efficient operation of the plants.

Regulators will need to make sure that the licensees are working to improve:

- the planning steps of the contract management process
  - ensuring they are being a more intelligent customer
  - integrating of the contractors into the licensee and plant safety culture
  - conducting formal project safety risk assessments as appropriate
- the effectiveness of communication by all parties and throughout the entire work process
- the level of continuous safety awareness by both licensee and contractor personnel

The regulators will also need to recognize how the aging of the work force and the potential difficulty of finding qualified staff may affect their own ability ensure the licensees are properly managing the contractor safety-related activities.

Regulators, licensees, and contractors will all need to:

- recognize the current and future contract management situations they face
- understand the safety implications of impending changes
- begin to take proactive actions
- continue to refine the actions as the situation warrants
- stay abreast of actions/programs that others are developing that might be appropriate for their situation

As a follow-on effort to this report, SKI has taken the initiative to develop a guidance document to support the SKI inspectors in recognizing and understanding the existing weaknesses with the contract management processes and the new challenges facing the licensees and contractors.

The format and style of the guide is based on previous SKI regulatory guidebooks on maintenance and operations. The information is organized along the lines of the contract management process and highlights the issues facing the licensees. These issues concern the existing implementation weaknesses and the impending safety-related challenges in the coming years due to; the aging of the workforce, the decline of the nuclear power industry, and the deregulation of nuclear power generation.

The SKI regulatory guide on the safety management of contractors is designed to be a useful resource for SKI, licensees, and contractors to ensure that all are taking timely and effective actions to proactively address safety-related contractor activities and improve plant and personnel safety.

Background

Contractors have always been an integral and important part of the design, construction, operation, and maintenance of nuclear power plants. The use of contractors has been a common practice within the nuclear industry worldwide. However, in recent years the nature and the amount of contracting activities have begun to change in some significant ways.

From the beginning nuclear plant licensees have instituted formal contract management processes to ensure the safe and efficient completion of contracted tasks. Over the years these processes have proven to be relatively effective for the procurement of support and components tailored to the needs of the nuclear power plants. However, incidents and accidents that were due in part to contractor-related activities have revealed some serious weaknesses with the *implementation* of these processes. These weaknesses warrant attention and improvement actions to avoid similar incidents and accidents in the future.

In addition to the existing weaknesses with the implementation of contract management processes, the nuclear industry is facing a number of organizational and personnel changes that are could significantly affect the ability to effectively monitor and mange the safety-related performance of contractors at the nuclear plants. The principal factors behind these changes are:

- the aging of the workforce
- the decline of the nuclear industry
- the deregulation of nuclear power

For example, due in part to the deregulation of nuclear power there have been numerous initiatives by the plant licensees in recent years to reduce expenses and make operations at their nuclear power plants more efficient. A common result of these optimization initiatives has been the increased use of contractors and the outsourcing of certain tasks.

A complicating issue is that the most experienced individuals within the nuclear industry are reaching retirement age. The potential loss in the coming years of experienced and knowledgeable personnel from the licensee organization, as well as from the regulatory and contractor organizations, will seriously test the ability to provide the additional oversight warranted by the anticipated increased use of contractors and outsourcing at nuclear plants.

The continuing weaknesses with the existing contract management processes in combination with the forthcoming organizational and personnel changes will create serious safety-related challenges for all those involved in the operation and oversight of nuclear power plants.

It is critical that the management and personnel from the regulatory, licensee, and contractor organizations recognize and understand the safety-related implications of these new challenges. Strategies and procedures will need to be developed in a timely

manner to avoid or minimize the risk associated with safety-related contractor work and to ensure the continued safe and efficient operation of the plants.

The Growing Awareness of the Problem

In recent years there has been increasing awareness within the nuclear industry of forthcoming problems related to the retirement of key staff members, the need to improve the contract management process, and the increased outsourcing of tasks and activities by the nuclear plant licensees. In response a Regulatory Industry Forum was held in June 2004 to address the issues associated with technical support services and contractors (NEA, 2004). This Forum was organized by the Committee on Nuclear Regulatory Activities (CNRA) of the Organization for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA). The two-day forum highlighted both the forthcoming challenges and the need for timely and coordinated actions. The importance of these issues can be noted in the extensive participation of senior management from nuclear regulatory organizations, licensees, and contractors worldwide. The information from this forum was a valuable resource in establishing the basis for this report.

In addition there are numerous initiatives focusing on specific aspects of the safety-related contractor activities. One such example is the work of the NEA CNRA Working Group on Inspection Practices (WGIP) on regulatory inspection of contracted work (NEA, 2003).

The following sections of this report build upon the work of the CNRA and numerous other organizations to categorize the key safety-related contractor issues facing the nuclear industry and to identify where organizations will need to focus attention in a timely, systematic, and efficient manner to avoid or minimize future safety-related contractor problems at nuclear power plants.

Report Objective – A Basis for Proactive Oversight

The objective of this report is to provide a review of current and potential future challenges facing safety-related contractor activities at nuclear power plants. The purpose is to assist the Swedish Nuclear Power Inspectorate (SKI) in establishing a strategy for the proactive oversight of contractor safety-related activities at Swedish nuclear power plants and facilities.

A proactive oversight strategy requires one to:

- be cognizant of potential problems
- understand the safety implications of new situations
- know where to focus attention and oversight resources

Report Structure

The nature and role of contractors at nuclear plants is briefly reviewed in the first section of the report. The second section describes the essential elements of the contract management process. Although organizations have had decades of experience with the contract management process, there remain a number of common implantation weaknesses that have lead to serious contractor-related incidents and accidents. These implementation weaknesses are summarized in the third section. The fourth section of the report highlights the forthcoming future challenges that face the nuclear industry. In this section the issues of facing licensees, contractors, and regulators due to the aging of the workforce, the decline of the nuclear industry, and the deregulation of nuclear power are discusses. The following three sections summarize the new or expanded roles and responsibilities that the contractors, licensees, and regulators will need to assume to effectively address the existing weaknesses with the contract management process and the forthcoming personnel and organizational challenges.

The Role of Contractors

Nuclear power plant contractors are often defined as any personnel working for a plant organization who are not directly employed by the plant organization (IAEA-a, 2000). The role of the contracted personnel is to perform tasks that are of a specialized or temporary nature where it is not desirable for various reasons to hire or maintain a permanent plant employee. Throughout this report the term contractor refers to vendors, manufactures, as well as contracted support organizations.

In certain situations licensee personnel that are not directly employed by the plant organization are also considered to be contractors (generally referred to as “internal contractors”). These are individuals that work for the licensee organization and are brought in from other facilities or locations to provide temporary assistance such as during the annual outage or for special modification work (IAEA-b, 2000). Although they are permanent employees of the licensee organization, the temporary nature of their work creates many of the same management and oversight issues that apply to external contractors.

Contractor organizations can range in size from large international engineering companies with tens of thousands of employees (e.g., BNFL with 23,000 personnel in 16 countries) down to single person consultancies.

The basic role of contractors is to provide specialized support in the form of people, tools, material, information, or management resources that is tailored to meet the needs of the licensee. The support tasks can range from administrative assistance to full turnkey design and construction of a power plant.

The variety of tasks and conditions where contractors are used at nuclear plants is all-encompassing and includes:

- the design and manufacture of both common and specialized equipment and components
- performing the assigned work either on the licensee's plant site or off-site at another location – for example, at the component manufacturing facility
- long-term and short-term assistance
- general services provided on a permanent basis – such as ground maintenance and food services
- management, technical, and administrative support
- augmentation of plant personnel for particular tasks
- the use of subcontractors in support of the main contractor

One area where contractors are not allowed to be engaged in Sweden and other countries is in the operation of the plant. Plant operators are required to be permanent employees of the licensee organization.

The majority of contract work is related to the maintenance and modification of the plant systems and equipment. Approximately eighty percent of the contracted work is usually performed during planned plant outages (Wiroth, 2004). However this percentage may change in coming years with more contractor work being performed during non-outage periods.

During refueling or planned outages the plant maintenance staff can be supplemented with anywhere from 500 to 2000 additional contract support personnel. The specific number of contractor personnel depends on such factors as the maintenance and modification requirements, the amount of specialized work, the length of the outage, the licensee's standard practices, and the availability of the licensee's own internal contractors.

As summarized below, licensees employ some form of a contract management process to ensure that the contracted projects are completed in a safe and cost effective manner.

The Contract Management Process

The contract management process is designed to assist individuals and organizations develop and maintain a proactive safety awareness approach to contracted work. The safety and quality management guidelines that constitute the contract management process provide a foundation upon which both the licensee and contractor personnel are provided the appropriate knowledge, tools, material, information, and coordination to be able to perform the work in a safe and efficient manner.

Over the years each licensee and plant organization has developed and refined their contract management process to meet their specific needs and plant requirements while ensuring the safe and efficient completion of contracted tasks. However, all contract

management processes consist of three basic phases. These are:

- planning and preparation
- performance management

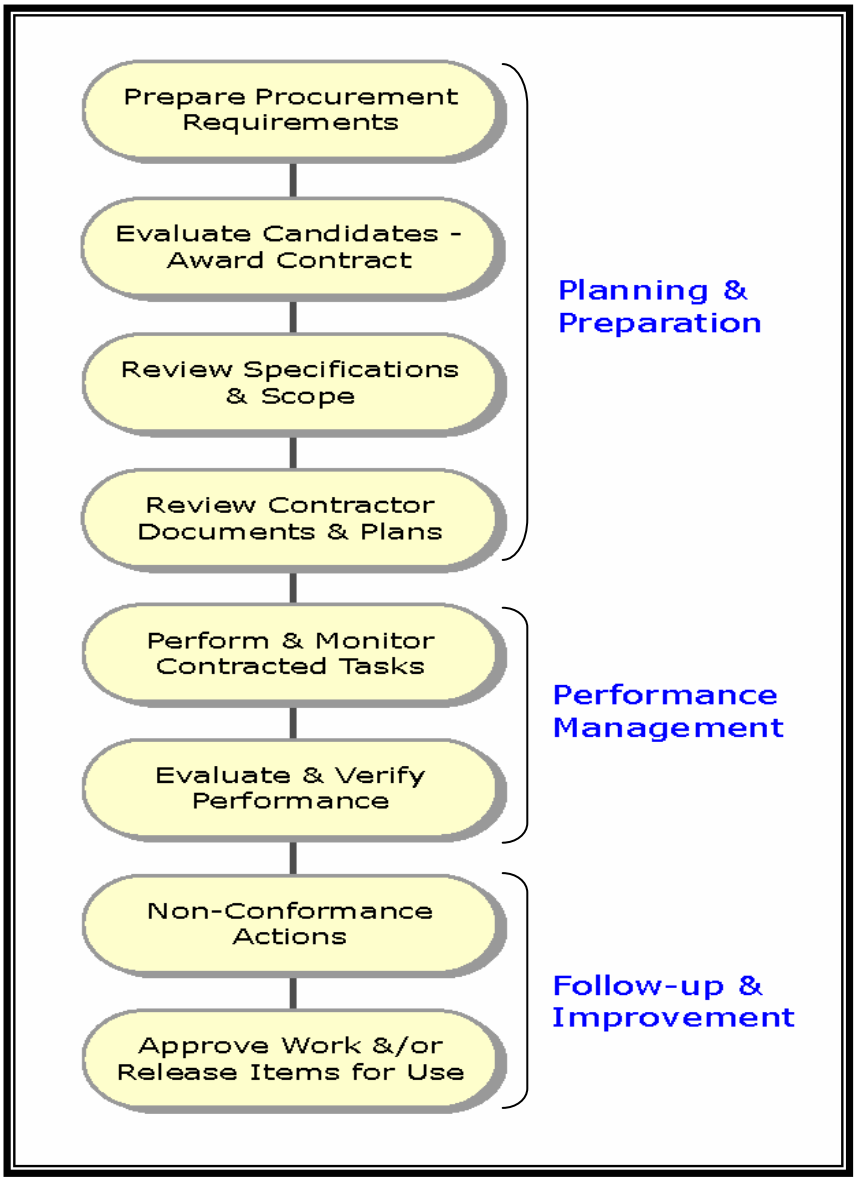

Figure 1: Essential Elements of Effective Contract Management Processes (IOSH, 2000; IAEA-a, 2000)

- follow-up and improvement

The three phases and the related essential elements are presented in Figure 1.

Each of the basic phases and the related key elements of the contract management process are reviewed below. Associated with each of the elements is a wealth of

detailed information, guidance, and best practices from such organizations as the IAEA to assist licensees in ensuring the contracted work is performed in a safe and efficient manner.

Planning and Preparation

Proper planning and preparation are essential for the successful and safe completion of any project. During the first part of the planning and preparation phase the licensee needs to define the work objectives and prepare the procurement specifications.

Once a contractor is selected, the licensee and contractor should work together to develop a mutual understanding of the safety significance, specifications, and scope of the tasks. For most projects the contractor will develop specific plans based on the licensee's initial project specifications. The final detailed work plan is usually prepared by the contractor and approved by the licensee prior to the commencement of work.

Effective planning and preparation activities that a licensee: (Nuclear Engineering International, 2002)

- develop realistic project objectives that do not compromise safety or quality
- ensure adequate time and resources for proper planning
- ensure safety considerations are integrated throughout the contract activities as appropriate
- document and communicate safety management processes, accountabilities, and regular monitoring requirements
- finalize the work plan using knowledge and experience of the contractor specialists
- establish understanding and agreement on suitable key performance indicators, including safety measures
- agreement on and communication of cooperative safety culture expectations
- considerations of licensee-contractor team building activities for safety significant activities

Performance Management

During the performance management phase of the contract, both the contractor and licensee have the responsibilities to ensure the safe and efficient completion of the assigned tasks. The contractor should carry out the assigned tasks (such as manufacturing, inspection, testing, document development, etc.) in a safe and efficient manner following the approved final plan and procedures. The licensee has the responsibility to monitor, evaluate, and verify that the quality of the work and services delivered are commensurate with the safety significance of the job and that the tasks are carried out in a manner that will not adversely affect the safe or reliable operation of the plant.

Several other important aspects of the performance management phase are:

- regular pre-planned performance review and feedback sessions
- formal process to communicate and manage changes, including revisions to the risk assessment
- agreement that safety significant changes must not proceed without an appropriate risk assessment
- manage contractor communication and coordination consistently and require contractor to do the same with subcontractor
- process to recognize and reward good practices by all those involved in the contract activities

Follow-up and Improvement

The follow-up and improvement phase consist of the activities necessary to ensure that the contract objectives are met and that the service or product meets all quality and safety standards.

Effective follow-up and improvement activities include: (IOSH, 2000)

- adopting a holistic approach to improvement that covers the licensee, contractor, and subcontractor
- establishing a process to capture lessons learned and identifying improvement opportunities
- routinely follow-up to determine if the implemented changes are effective
- ensuring licensee and contractor feedback is linked to agreed contract performance standards and expectations
- linking feedback and continuous improvement initiatives by the contractor to future contract considerations

For large outage projects it is common for the licensee to hold a "lessons learned" review with the contractor. Generally this review tends to focus on the actions of the contractor personnel. To be most useful, the review should address both the actions of the contractor and the licensee. Unfortunately, for many other types of contract work the feedback activity is often forgotten or ignored.

Implementation Weaknesses

The primary fault of the contract management process is generally not the absence of procedures or documented requirements, but rather the lack of effective implementation.

In 2004 the Committee on Nuclear Regulatory Activities (CNRA) of the OECD Nuclear Energy Agency conducted a review of recent events related to contracted work (NEA, 2004). The objective of this review was to provide a summary of the actions involving

contractor tasks that were the root cause or contributing factors to safety significant accidents and incidents. A number of these events are presented below to highlight common weaknesses in the implementation of contract management processes.

It should be noted that the events listed in the database used by the CNRA represent the "tip of the iceberg". In most cases the failure to implement certain steps in the contract management process creates only minor problems and near misses which do not have any serious consequences. Licensees are usually not required to report these near misses to the regulatory organization.

However, serious accidents and incidents are almost always the result of an unfortunate combination of minor problems and system weaknesses. To avoid accidents and incidents it is therefore essential that the minor problems be recognized and properly addressed in a timely manner by both the licensee and contractor.

The four most common weaknesses that were found to be primary or contributing causes to reported contractor related accidents and incidents were:

- the lack of supervision
- design changes
- inadequate training
- the lack of safety awareness

Lack of Supervision

The predominant contributing factor mentioned was the lack of supervision of contracted work by the licensees. Two such examples are presented in Figure 2.

Often associated with the lack of supervision are:

- deficiencies in the quality assurance programs of the licensee and contractor
- incomplete or insufficient documentation

Event findings concerning the lack of supervision included statements such as: (NEA, 2004)

- "…lack of licensee's review of vendor information"
- "…lack of vendor's information leading to ineffective preventive maintenance"
- "The drawings, operating guides and maintenance instructions included no specific indications concerning the appropriate material for retainers."
- "…inadequate monitoring of system cleanliness on completion of maintenance work."
- "…inadequate oversight of contractor and subcontractor activities"

Two Examples of
Inadequate Licensee Supervision & Oversight

(NEA, 2004)

Event 1

The licensee directed a contractor to inject sealant into the vessel head venting system (HVS) to repair a leak that was detected downstream of a flow-gauge isolation valve. During the post-maintenance testing it was found that some sealant had migrated to other portions of the HVS and clogged two HVS control valves. The result was the non operability of the HVS system and possible impact on the ability to respond to accident conditions.

Among the contributing factors were:

- wrong sealant used due to improper information from the licensee
- licensee did not adequately review the contractor's activities (i.e., quality assurance procedures)
- licensee's work instructions, prebriefings, and overall oversight were inadequate

Event 2

In another situation at the plant sealant was injected to repair cracks in the floor of the service water (SW) building. This floor was also the roof of the SW intake tunnel. The sealant migrated into the nonessential SW system and clogged the in-line strainers. This resulted in a decrease in the discharge pressures of the SW system. The strainers were back-washed and normal discharge pressure was restored.

The sealant was later found to also have caused high temperatures in a diesel fire pump due to clogging of the coolant system.

The regulator concluded root cause of strainer fouling was poor control of the work on safety-related structures. Among the contributing factors were:

- responsible licensee staff was not knowledgeable enough with the facility to recognize potential consequences of the work
- contractor was not aware of the potential impact of the work
- contractor had no approved procedures
- licensee did not provide adequate oversight

Figure 2: Two Examples of Inadequate Licensee Supervision and Oversight

Design Issues

Design changes were identified as the root or contributing cause in many events. Often apparent minor changes or modifications can lead to potentially serious safety situations.

Design changes themselves are usually not the problem. Rather, the problem is:

- the failure to recognize the potential safety significance of the changes
- not following quality assurance procedures
- not properly informing others of the changes

Design related issues that have contributed to contractor-related events have included: (NEA, 2004)

- "…potential errors in reactivity calculations for spent fuel pools were approximations used in the calculations"
- "…underestimating the safety consequences in the design of the cleaning cask"
- "…initial error in the design and construction"

In addition, a common problem is that licensee personnel are unaware of design or construction errors from when the plant was original built. Not built as designed is an often mentioned situation. In one case, a plant had been in operation for over twenty years before design errors and the wrong installation of components and equipment was noticed. Not recognizing such situations can create serious problems when contracting for repair or replacement activities.

Two examples of the safety-related consequences due to undocumented design changes are shown in Figure 3.

Examples of Undocumented Design Changes

(NEA, 2004)

In two events the emergency diesels failed to start during functional tests.

Event 1

The first situation was due to the use of a new lower sulfur fuel to meet environmental requirements. It resulted in increased friction in the control sleeve of the governor and the blocking of the controller.

Event 2

The second failure of the diesel to start was due to the change of an O-ring seal in the internals of the solenoid valves used for air start-up. The licensee was not informed of the change and the plant acceptance conformance test had not detected the change.

The resulting safety risk from these events was low, but the potential existed for a much more significant common mode safety situation.

Root Causes

The root cause of the first event was the change in fuel was made without informing the licensee and therefore no risk assessment was done on the safety impacts of the change.

The cause of the second failure to start was due to:

- design changed without an adequate qualifications test of the solenoid valves
- not informing the licensee of the design change

Figure 3: Examples of Undocumented Design Changes

Inadequate Training

Another fundamental problem that has contributed to a number of recent contractor-related events has been incorrect assumptions about a person's skills and knowledge. Such assumptions have lead to insufficient or ineffective training of the licensee, contractor, and subcontractor personnel.

Serious safety-related events were found to be due in part to the fact that the contractor personnel:

- lacked knowledge about the equipment operation
- were unaware of the safety significance of their work assignment
- did not have information about or copies of the quality assurance procedures

Investigations concluded that several events were due in part to deficiencies in the training of licensee staff. Their lack of training lead to:

- the failure to comply with regulatory requirements and procedures
- carelessness
- lack of self-assessment

Figure 4 provides a recent example of and inappropriate assumptions about the skills and specific plant knowledge (and consequently inadequate training) of internal contractors lead to a serious safety-related incident.

Example of Inadequate Training

(NEA, 2004)

During a hydrostatic test of the reactor vessel, the instrument and control (I&C) "internal contractor" technicians in the control room began an instrument line flow check valve operability test. The control room operator was monitoring the pressure to control the reactor vessel hydrostatic test pressure. The operator was unaware of the I&C test activities and attempted to raise the pressure. The result was an alternate control rod insertion and recirculation pump trips.

Several contributing factors were identified, including:

- internal contractors are screened for basic instrumentation knowledge and not plant-specific operational procedures
- lack of effective communication between plant operators and I&C technician within the control room
- I&C technician who acted as communicator was hired as an internal short-term contractor for the outage
- I&C technician not familiar with the operations crew and did not recognize procedural inconsistencies or deficiencies

Figure 4: An Example of Inadequate Training and Inappropriate Assumptions of Plant Knowledge

Lack of Safety Awareness & Communication

The event at the Paks nuclear power plant in 2003 (Figure 5) highlighted a number of common weaknesses with the implementation of effective contract management processes, including excessive trust in the contractor and emphasis on schedule and production over plant safety.

Excessive Trust in the Contractor

(HAEA, 2003; IAEA, 2003; NEA, 2004)

In early 2003 the fuel assemblies from the Paks nuclear power plant (Unit 2) in Hungary were being cleaned in a special device installed in the fuel pool. This cleaning had been necessitated by magnetite deposits on the fuel assemblies.

Three years earlier Paks had contracted with a major international nuclear company to clean 170 fuel assemblies. The cleaning operation was accomplished successfully using standard technology in a vessel containing seven fuel assemblies at one time.

For the job in 2003 the Paks management retained the services of the same international company. But this time the company developed a vessel and cleaning technology to handle 30 assemblies at one time.

At the completion of the cleaning of one group of 30 assemblies, the assemblies overheated due to a lack of sufficient cooling. This resulted in severe fuel damage and the release of fission products. There was detectable elevated radiation readings off-site and slight contamination in the reactor hall. Among the causes identified were:

- excessive trust in the contractor supplying the cleaning device
- decrease in the plant safety culture
- underestimation of safety consequences in the design of the cleaning cask
- lack of regulatory oversight in licensing and inspection
- lack of competence and procedures for the cleaning operation itself
- stress of time and emphasis of production over plant safety

Figure 5: An Example of Excessive Trust in the Contractor

In reviewing these contractor related incidents and accidents there appears to be two fundamental underlying issues. The first is the lack of continuous safety awareness by contractor and licensee personnel. During the performance of the assigned tasks people periodically fail to notice the safety implications of their actions or potential hazards from unanticipated changes. This is possibly due to such reasons as limited experience, poor information, fatigue, excessive task familiarity and complacency, or inadequate guidance and supervision.

Although not all activities have the same safety significance, a key part of the proper planning and preparation phase is determining the level of safety significance and developing an appropriate work plan. Often mistakes are made in planning and corners are cut during the conduct of tasks with no serious consequences to either the individual

or the equipment. However, in certain situations a series of minor mistakes, deviations, and complacencies can and have combined to create a serious accident.

It is the responsibility of each person to be aware of safety implications of their work and their work situation.

A second fundamental underlying issue noted in most all contractor related events is the lack of effective communication. There are often neither formal nor informal communication channels to ensure that safety-related information is provided to all appropriate individuals in a timely and efficient manner. In addition, contractors are seldom provided financial incentives to document and report safety concerns and observations.

Impending Challenges Facing the Nuclear Industry

In addition to the weaknesses in the implementation of the contract management process discussed in the previous section, there are a number of impending or forthcoming industry-wide changes that are expected to have significant impacts on the ability to effectively monitor and mange the safety-related performance of contractors at the nuclear plants. The three driving factors behind the changes are:

- the aging of the workforce
- the decline of the nuclear industry
- the deregulation of nuclear power

Aging of the Workforce

There are two aspects to the aging of the workforce that are expected to have significant impacts on contractor activities in the coming years. These are:

- the aging of the general working population
- the aging of the individual worker

Aging of the Workforce Population

The baby boom generation that was born after the end of World War II came into the job market around the same time the nuclear power industry was at its peak. Today, many of those working in the industry are beginning to reach retirement age. The average age of people working at many nuclear power plants is over 50 (Nuclear Engineering International, 2002). The concern is with the sudden loss of a major portion of the most experienced, skilled, and knowledgeable staff from all areas of the organization. For example, it is anticipated that within six to seven years about 25 percent of the nuclear workforce in the United Sates (US) will be at or near retirement age. At one US licensee 50 percent of their staff will be eligible for retirement by 2007 (Nuclear Engineering International, 2002).

Similar potential losses of staff have been identified within contractor support companies such as BNFL-Westinghouse and at the regulatory organizations such as the

Health and Safety Executive (HSE) in the UK (Nuclear Engineering International, 2002).

With the loss of experienced and knowledgeable staff from contractor organizations, it has been suggested that additional licensee monitoring and supervision of the contractor work tasks may required. Unfortunately, the licensee personnel that are the most familiar and experienced in monitoring the contract process and overseeing the contractor's work activities will be retiring as well. This will include licensee personnel involved in such areas as maintenance, health physics, and contract administration.

It is anticipated that the loss of such competence from the licensee organization may require the use of outsourced assistance to define, supervise, and evaluate the contractors' work. The assistance will need to be provided by competent contracted organizations that do not have a vested interest in the project. However, with fewer experienced and competent organizations available to provide such independent support there may likely be problems with conflicts of interest as has been recently experienced in the US military. Over the past decade the US military has been working to reduce contracting costs. This has involved a major reduction of awards to small contracting organizations and a transfer of the work to the major contracting companies. Another part of the cost reduction effort has been the elimination of many of the most experienced contract management administrative personnel. At the same time there has been a consolidation of the major contracting companies resulting in fewer resource options for the military.

The result has been the lack of independent contractors that can assist in the evaluation of proprietary information from a competitor to verify the design meets the safety requirements. This situation is very likely to arise within the nuclear power industry in the coming years as well.

The concern within both the nuclear industry and other industries is how best to transfer the knowledge from the older, experienced personnel to younger staff. The application of knowledge management to the nuclear industry has become a major initiative in recent years. The conclusion from a recent IAEA knowledge management conference was that there are no clear methods to easily transfer knowledge and experience (IAEA-2004). For example, Westinghouse and other organizations have mentoring-type programs to pair up a younger person with senior technical staff members. This approach has proven successful within the maintenance crafts area for many years. But the disadvantage of such a one-on-one training program was seen when a younger staff members decided move on for other opportunities after the organization had invested many months or even years in the transfer of knowledge and skills.

Although the IAEA has continued to emphasize the importance of the knowledge management issue over the last few years, it is clear that there still remains a critical need for more efficient and less burdensome means to capture and transfer nuclear knowledge.

Teollisuuuden Voima Oy (TVO), the Finnish nuclear plant licensee, has established a program to provide them time to address the knowledge management issue (Raastas,

2004). The program is designed to encourage senior workers to continue their employment beyond the date at which they can retire. The objective is to retain the necessary competencies and experts within their organization thereby giving them more time to transfer their skills and knowledge to younger personnel.

Many organizations have been identifying necessary key competencies within their company and within each organizational unit. This information is being used for training development and succession planning purposes.

Aging of the Individual Worker

As the individual worker gets older there are several issues that may impact the nature and safety of contractor activities at nuclear power plants. There have been a number of studies over the years examining human errors and the decrease of physical and mental capabilities of older workers (Haight, 2003). The concern is that many of the contracted tasks place high demands on memory, vision, range of motion, strength, decision making, and reaction capabilities. There are all capabilities that tend to deteriorate with age. Studies have shown that although age-related performance decrement begins to occur in those over the age of 45, it does not appear to become significant until around the age of 50 (Haight, 2003).

The Finnish Institute of Occupational Health (FIOH) has instituted an approach to attempt to manage both the physical and mental changes that accompany aging for workers over 50 (Ilmarinen, 2001). The impetus for the development of the work ability program was the recognition that the population in Finland is aging more rapidly than anywhere else in Europe. The objective of the program is to balance personal factors such as health, skills, and motivation with the job. Work assignments are structured to address the aging requirements of each worker.

In addition to promoting the work ability concept, the management at certain Finnish companies has set up a complimentary program to capture knowledge and ensure it can be passed on to younger workers. In many cases when restructuring the work assignments as part of the work ability program, the older staff member is assigned the role of an internal knowledge expert that younger workers can go to for advice and guidance.

Decline of the Nuclear Industry

In most countries the nuclear power industry reached its peak in the 1970s and early 1980s. In many countries there have been no new plants built for over ten years. For various political and economic reasons many nuclear plants have been decommissioned before they ever reached their end of design life. Although there are strong initiatives by the industry to upgrade existing plants and extend their operating life, the general perception in many countries is that the nuclear industry is in decline and slowly dying.

Even though the industry has shown a strong commitment for continued operation of existing plants, there are two potentially serious problems that have been created by the lack of new construction activities. These are:

- the shortage of young people entering the nuclear engineering field
- the decrease of nuclear contractor organizations

Shortage of Young People Entering the Nuclear Field

As discussed above, there will be large number of people retiring from the nuclear industry in the not-to-distant future. Unfortunately, it will be difficult to replace them with qualified replacements at an equivalent rate.

The Department of Trade and Industry in UK anticipates the primary need for the nuclear industry in coming years will be to recruit and retain good quality scientist, engineers, and skilled technicians (Nuclear Engineering International, 2002). The falling number of available graduates in the appropriate engineering fields could potentially impact the ability to continue to safely maintain and operate the plants.

Although the shortage of technically competent people entering the industry does not appear to be a problem in Sweden at this time, it could be a problem in coming years. Between 1998 and 2000 the number of engineering graduates in the Swedish nuclear program fell by 80 percent (Nuclear Engineering International, 2002). In Japan there have been decreases in the number of: (Fujii, 2004)

- students applying for nuclear engineering
- nuclear education programs
- recruitment activities by the nuclear industry

In the US it is estimated that there will be serious staffing shortages in the next ten years for health physicist and nuclear engineers (Howard, 2002). Even assuming that all graduating health physicists in the next ten years enter the US nuclear industry, there will still be a shortage of over 700 qualified health physicists.

Although certain contractor organizations have large amounts of decommissioning contract work available they are having difficulties in attracting people to become involved in the work.

Whatever the reasons behind the reluctance of people to join the nuclear field, it is anticipated that licensees, contractors, and regulators in every country will likely be affected by the staffing problem in coming years.

There are currently numerous national and international efforts to encourage people to enter the nuclear field. Although there appears to be some success in reversing the declining trend in some countries, these are long term efforts and it is not clear if they will be successful in time to counter the wave of anticipated retirements.

The Decrease of Nuclear Contractor Organizations

The decline of new plant construction has resulted in many vendors and manufacturers leaving the nuclear power market. This has been taking place for many years and continues to create problems for the licensees when they need to obtain "nuclear grade" replacement parts for safety systems.

For those organizations that have continued to support the nuclear industry there have been some major organizational changes over the years. Many of the companies that were major actors in the development of the nuclear plants are no longer in existence. Many joined with or were acquired by other contractor companies.

Some of the potential problems these situations may create are the loss of:

- contractor safety culture – difficulties in establishing a consistent safety culture
- institutional memory – loss of technical information as staff are integrated into the new organization
- contracting options – reduced number of contractor resources available for the licensees to choose among
- long term partnering options – difficulty to ensure long term cooperative efforts between licensee and contractor when companies are being sold and reorganized

Another problem inherent is the internationalization of large contractors. This has increased the issues associated with multi-national contractor crews, and the problems with language, communication, coordination, and cultural awareness.

Deregulation of Nuclear Power

The deregulation of nuclear power in recent years has resulted in a number of initiatives by licensees to reduce expenses and make operations more efficient. Two actions that could create difficulties for the licensee to ensure the safe and efficient conduct of contracted work are:

- increased outsourcing
- utility mergers and acquisitions

Increased Outsourcing

The outsourcing of certain jobs or activities has been a common practice at many nuclear and non-nuclear operations. The jobs that have been outsourced are those that the organization does not desire to include within its core capabilities. Examples include janitorial service, food services, and travel services. But there appears to be a growing interest by the licensee organizations to consider outsourcing activities that could have a greater impact on the safe operation of the plant. These could include maintenance, procurement, and health physics.

There are numerous studies that indicate that outsourcing has proven to be economically beneficial for many companies (Sullivan and Shelgren, 2004). For example, 76 percent

of major US and European companies outsource one or more major human resource functions (Accenture, 2004). Eighty percent of the companies indicated they would outsource again and none plan to take the outsourced services back in-house.

There are several factors that, if applied in the same manner by the nuclear plant licensees, could warrant close attention. One factor is that most companies blended the human resource management services, using both internal and external capabilities and multiple providers. Another factor is that there have been "initial growing pains". Originally, these companies had no dedicated outsourcing management group. However, based on their experiences to date, about two-thirds of the companies surveyed have now begun to create an internal group dedicated to managing their outsourcing activities.

In reviewing such programs it was stated that the benefits of outsourcing are gained only when the outsourcing provider becomes integrated into the organization's culture and the aims of the contracted work are clearly communicated across both the contracting and contractor organizations (Hawk, 2004).

Utility Mergers and Acquisitions

A major consequence of deregulation has been the many mergers and acquisitions that have taken place among electric power utilities. Many of these have been international mergers and acquisitions. From the contractor's perspective the key issue with respect to the changes in ownership is the ability to understand and integrate their activities into the changing organizational and safety culture.

Increased Responsibilities for Contractors

Based on the lessons learned from past contractor-related incidents and accidents and the impending challenges facing the industry, contractors and licensees will need to take on new or expanded roles and responsibilities. For example, contractors will need to take a much more structured and formal approach to assessing the nature of the work from both an economic and safety standpoint.

Contractor personnel encounter problems similar to those that challenge licensee personnel, such as the compliance with procedures, communications and coordination, teamwork, work in hazardous environments, and concerns about nuclear safety. Prior to accepting a job assignment, as well as during the performance of the work, the contractor needs to assess the nature of the work from both an economic and safety standpoint. The contractor has a responsibility to assess the health and safety implications related to:

- their own personnel and to any subcontractor personnel
- other personnel at the plant
- the general public

The objective of the contractor performing a safety assessment is to make any necessary changes in the work methodology, materials, or sequence early enough to avoid or reduce the risks of personnel injury or equipment damage.

Assessment of Project Safety Risk

In the past the assessment of project risk has often been done routinely in an "informal" manner. However, in recent years there have been major initiatives within the nuclear power industry and in many other industries to establish more "formal" risk assessment processes (Figure 6). Increasingly these formal risk assessment methodologies are being incorporated into industrial codes and standards.

Not all contractor activities and tasks have the same potential safety implications. It is the responsibility of the licensee to make an initial determination of the general level of plant and personnel risk associated with the proposed work tasks. The chosen contractor has the responsibility to use their expertise and knowledge and work with the licensee to refine the initial risk assessment.

Together the contractor and licensee should review the specifications and scope of the work prior to finalizing the work plan. Both organizations have a responsibility to avoid or minimize any risks inherent in the work assignments. By conducting the risk assessment as a joint effort, there are several benefits to be realized, including:

- identifying both personnel safety and plant safety issues
- strengthening the work plan
- ensuring that those doing the tasks understand the safety issues involved
- improving communication between the contractor and the licensee personnel
- identifying (and documenting) where, when, and how to monitor the safety-related contractor activities

Formal Project Risk Assessment Process

1 Identify Safety Hazards
- due to the task or from adjacent activities
- in sufficient time to make changes and inform personnel

2 Identify Harm or Damage
- to those doing the work
- to others that might be affected
- to systems and components

3 Evaluate Risks
- assess the severity and likelihood of harm occurring to workers and to systems and components
- identify how to avoid or reduce risks

4 Document Findings
- record findings, actions to be taken, & rationale
- provide results to all appropriate parties
- keep it simple

5 Review & Revise

As work progresses:
- review assumptions & identify any new hazards
- make needed changes
- inform all relevant parties

Figure 6: Basic Steps of Formal Risk Assessment (HSE, 1999; Main, 2002)

A formal risk assessment of the project work assignment would involve the following five steps:

- identify potential safety hazards
- identify the potential harm or damage
- evaluate risks – the probability of harm multiplied by the potential consequences
- document the findings
- review and revise the assessment throughout the work assignment

Some of the key points associated with each step of the formal risk assessment process are presented in Figure 6.

There are a wide variety of risk assessment methodologies available to the contractors and licensees, from basic qualitative approaches to detailed quantitative approaches. The methodology that organizations may use generally depends on such factors as:

- the apparent safety significance and complexity of the tasks to be performed
- the familiarity of the assessment team with one approach or another
- the availability of quantitative data

Due to the lack of quantitative, or "hard", data in most situations, it is often not possible to develop precise estimates of risk. Rather the results should be based on both the data that are available and on engineering judgment. The combination of experience and expertise that the contractor specialists and the plant personnel bring to the process is essential to ensure that all safety implications are recognized. Without the input and insights of the contractor specialists it is possible that safety critical factors may be missed.

In general the formal risk assessment approach outlined in Figure 6 is not that different from what most organizations have been doing for years in a more informal manner. However, one key difference of the formal process is the requirement to document the findings and the rationale behind them. A second key difference is the requirement that all relevant parties need to be kept informed of the results from the assessment.

Such documentation and communication among personnel and organizations will become even more important in coming years as the more experienced contractor, licensee, and regulatory staff members retire. In the future well documented assessments of past contractor activities will help avoid problems and minimize the safety risks associated with similar work.

Another important benefit of the formal project safety risk assessment is that it assists the licensee in establishing and communicating the scope and timing of the oversight of the contractor's work. Similarly, appropriate regulatory oversight actions are dependent in large part on the level of safety significance identified by the risk assessment. By working on the assessment in coordination with the licensee, the contractor gains an understanding of not only the safety significance of the work but also the associated management and oversight requirements.

Recognizing and Reporting Changes

As work progresses there should be on-going safety dialogue between the contractor and licensee. Both those managing and those performing the work tasks should be aware of changes that could increase the safety risk of the work. It is common that there are changes in work priorities, task sequence, or unanticipated situations arise that could impact the level of risk originally envisioned for the project tasks. Often these may appear to be minor changes but in combination with other actions they could pose an increased safety risk to the personnel or plant.

It is the responsibility of the contractor to be alert to such changes and alert the licensee to the situation in a timely manner. Often in the past there have been cost and schedule pressures that have created disincentives for the contractor to report anything that might modify or delay the work activities. It is therefore important that the contractor and licensee ensure that the contract agreement is structured with appropriate incentives to encourage contractor personnel to report safety concerns throughout the course of the project.

Increased Responsibilities for Licensee

Licensees can not delegate plant safety. Although a licensee can delegate authority to a contractor to perform tasks on its behalf, in no case can the licensee delegate its prime responsibility for the safety of the plant (NEA, 2003). Consequently, it is the responsibility of the licensee to ensure that the contractor meets all the relevant quality and safety standards.

Over the forty year history of the nuclear power industry each licensee and plant organization has developed, tailored, and refined their contract management process to meet their specific needs and plant requirements while ensuring the safe and efficient completion of contracted tasks.

However, in light of the continuing weaknesses with the implementation of the contract management process and the impending changes facing the industry, licensees must begin to direct more attention to the safety-related activities of their contractors.

The licensees will need to ensure that they are:

- being an “intelligent customer”
- integrating the contractor personnel into the plant safety culture
- being proactive

Being an “Intelligent Customer”

The licensee must have the technical and managerial competence to understand the task requirements and the safety implications of any proposed work. Competence comprises the skills, knowledge, and attitudes required to perform the assigned tasks in a safe and

efficient manner. These attributes are developed through the combination of education, experience, and training.

Although it is preferable that the necessary technical and managerial competence reside within the licensee's organization, in certain situations this may not be possible. Part of being an "intelligent customer" (also referred to as a "knowledgeable customer") is to:

- recognize when one does not have the necessary competence
- obtain the appropriate guidance and assistance
- obtain the appropriate guidance and assistance

When a licensee does not recognize either their lack of competence or the safety significance of the proposed tasks, it is possible to inadvertently delegate the responsibility for the safety of the plant to the contractor. This was the case at the Paks nuclear power plant in 2003 during a fuel cleaning operation (see Figure 5). The regulatory review of the event found that neither the staff nor the contractor fully understood the dangers of the process. The regulator also stated that the Paks plant "…endangered safety by applying the principle of 'blind' trust towards its contractor" (HAEA, 2003).

It can be easy to put excessive trust in the contractor's abilities, especially if the contractor has successfully performed similar jobs at the plant in the past.

The need to be an intelligent customer also applies to the contractor whenever they subcontract out a portion of the work to another organization. In this situation the prime contractor is responsible to ensure that the subcontractor meets all the relevant quality and safety standards. The prime contractor must also have the technical and managerial competence to understand the subcontracted task requirements and the safety implications of any proposed work or must obtain that competence from others.

Integrating Contractors into the Plant Safety Culture

Safety culture is generally defined as the combination of beliefs, shared values, and behaviors reflected in making decisions and performing work (IAEA, 2002)

The development and improvement of the safety culture at a plant is a critical part of the job of the licensee management and staff. In order to achieve a high level of safety culture, the licensee must establish and conscientiously apply a set of values in which the highest priority is that issues receive the attention warranted by their safety significance. This requires the systematic organization and implementation of a number of activities aimed at creating a high quality defense in depth against both technical and human failures that may cause accidents.

The development of the safety culture is a continually evolving process influenced by such factors as:

- the support by management for, and daily demonstration of, safety principles
- the involvement of management in addressing safety issues

- efforts by the staff to improve their performance, education, and safety training

Whenever a contractor performs a task on behave of the licensee, they should be considered to be an integral part of the licensee's organization. The contract personnel should work to the same safety and quality standards as would a licensee staff member (IAEA, 2002). All the resource support that is assigned to a licensee staff performing the work should be provided to the contractor personnel. This includes people, materials, tools, information, and coordination resources.

Both the licensee and the contractor need to recognize and address potential differences between the safety culture at the plant and the safety culture of the contractor organization. For example, if personnel have never worked at a nuclear power plant before and they require unescorted access to work on safety-related components, they must proceed through an administrative review process to verify such conditions as their qualifications, competence, fitness for duty, and personal background.

Once through the administrative process there are three key elements to ensure that the contractor personnel are integrated to the extent possible into the licensee's safety culture. These are:

- orientation of contractor personnel
- continuous communication
- oversight of contractor work performance

Contractor orientation for those working at the plant site usually involves a number of training sessions. The training is to provide the contractor personnel with information such as:

- basic nuclear knowledge
- radiological protection
- quality assurance
- plant security
- lock-out tag-out practices
- evacuation fire and hazard alarms
- fitness for duty responsibilities
- specific plant and project safety issues
- nuclear access procedures and requirements

Some or all of these training sessions may be required on an annual basis for contractor staff returning to the plant site. The specific nature and level of training will depend on the safety significance of the contracted tasks.

Continuous communication is the second element in ensuring that the contractor personnel are integrated into the licensee's safety culture. This starts with work packages, pre-job planning, coordination with relevant plant departments, and information on hold points, inspections, and testing requirements. Throughout the work assignment, the contractor personnel should be included in all relevant plant safety

review meetings and communications. The contractor personnel should report any factors that may affect their ability to safely perform the assigned tasks, the safety of others, or the safety of the plant.

The degree of oversight or direct supervision of the contractor's work by the licensee will depend on such factors as the type of work being performed and the specific experience and background of the contractor personnel and not just the experience of the contractor organization. All oversight should be performed in accordance with licensee safety standards and safety culture (IAEA, 2002; Hoegberg, 1994).

An important consideration in defining the level of oversight is the fact that contractor personnel will never have the same level of "ownership" in the plant operations as do the permanent licensee staff. The fact that contractors do not have the same level of ownership or detailed understanding of plant specific issues requires greater attention by the licensee to the safety related aspects and implications of a contractor's actions than if the work was being performed by licensee plant personnel.

One way that most licensees in the past have attempted to improve the contractor's level of commitment and understanding has been to establish long-term relationships. By working together with the plant staff over the years the contractor personnel can become more familiar with the specific safety culture issues at the plant. But this option may not be as effective or available in the future. The consolidation of contractor organizations, the economic pressures from deregulation, and the anticipated loss of personnel may limit the ability to establish such long-term relationships.

Being Proactive

A basic premise of all the procedures and requirements associated with contracting support or acquiring materials is to be proactive in avoiding problems that could result in injury to the personnel, damage to the equipment, or harm to the public.

To be proactive it is necessary to:

- be cognizant of potential problems
- understand the safety implications of new situations
- know where to focus attention and oversight resources

This requires the licensee to have done a proper and thorough preparation and planning of the work to be performed by the contractor. The licensee must take the time and effort to clearly identify and define the project objectives, the safety significance of the tasks, and establish and communicate the scope and timing of the oversight of the contractor's work.

In addition, all parties involved in the contract management process should have a questioning attitude and look for areas where improvements can be made. Clear and open communication is an essential part of being proactive and improving all aspects of the contract management process.

New Challenges for Regulatory Oversight

The key challenge for regulatory oversight of safety-related maintenance contractor activities is to ensure that licensees are being proactive and that they are recognizing and addressing the safety-related implications of the changing environment for contractor work. The regulator needs to be assured that strategies and procedures are being developed in a timely manner to avoid or minimize the risk associated with safety-related contractor work and to ensure the continued safe and efficient operation of the plants.

Regulators will need to make sure that the licensees are working to improve:

- the planning steps of the contract management process
  - ensuring they are being a more intelligent customer
  - integrating of the contractors into the licensee and plant safety culture
  - conducting formal project safety risk assessments as appropriate
- the effectiveness of communication by all parties and throughout the entire work process
- the level of continuous safety awareness by both licensee and contractor personnel

The regulators will also need to recognize how the aging of the work force and the potential difficulty of finding qualified staff may affect their own ability ensure the licensees are properly managing the contractor safety-related activities.

Regulators, licensees, and contractors will all need to:

- recognize the current and future contract management situations they face
- understand the safety implications of impending changes
- begin to take proactive actions
- continue to refine the actions as the situation warrants
- stay abreast of actions/programs that others are developing that might be appropriate for their situation

As a follow-on effort to this report, SKI has taken the initiative to develop a guidance document to support the SKI inspectors in recognizing and understanding the existing weaknesses with the contract management processes and the new challenges facing the licensees and contractors.

The format and style of the guide is based on previous SKI regulatory guidebooks on maintenance and operations. The information is organized along the lines of the contract management process and highlights the issues facing the licensees. These issues concern the existing implementation weaknesses and the impending safety-related challenges in the coming years due to; the aging of the workforce, the decline of the nuclear power industry, and the deregulation of nuclear power generation.

The SKI regulatory guide on the safety management of contractors is designed to be a useful resource for SKI, licensees, and contractors to ensure that all are taking timely and effective actions to proactively address safety-related contractor activities and improve plant and personnel safety.

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