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Safety Engineering and the Design Review Process – "Prevention through Design"

Jeffrey L. Robinson, PE, CSP
President – Robinson Risk Consulting, LLC
Aiken, SC

Introduction

The Comprehensive Review for Projects (CRP) is a formal review process during the planning and design, construction, installation, and startup of a system, process, or piece of equipment. The process is designed to enhance the probability of project success by increasing the likelihood of improved project
performance, thereby decreasing the likelihood of unanticipated cost overruns, schedule delays, and compromises in quality and safety.

A motivation for this presentation and the subject matter were based on the significant number of issues identified during a round table held at the 2010 PDC in Baltimore, MD. The purpose of the round table was to identify the challenges that safety professionals face when dealing with design reviews for projects. Twenty safety professionals attended this round table and identified the following issues.

- Safety professionals are not comfortable with the design review process.
- Design engineers do not understand the safety issues.
- Safety professionals are not being integrated into the design phase of the project.
- Fast-paced projects lead to partial information being made available to the safety professional and then their input is sought either too late in the process or before adequate information is available.
- Safety professionals are more multi-faceted and so they are less confident in the design review phase.
- Building codes are not consistent with safety standards.
- Design intent is often different from what is actually built in the field.
- Fast-tracked reviews are often focused on profits and business needs.
- Review process is not comprehensive – it happens in series vs. all at one time (all-at-one-time review is perceived by the group as being a better approach)
- Facility management is not educated to understand the cost benefits from safety retrofits.
- Safety professionals are always the last ones to be brought into a design review and often this is too late.

- Integrate end user needs into the design review – operational and maintenance needs are not considered in the design review.
- There is not a culture of acceptance for Prevention through Design.
- There are no OSHA requirements for safety design reviews.

Scope/Purpose

The CRP is designed to ensure that effective safety; health, environmental, quality, security and asset conservation management are "designed and built into" facilities. Facilities work to manage assets for maximum productivity and minimum losses while complying with all applicable regulatory requirements. This process sets out the requirements for formal reviews of all projects and modifications and provides both structure and tools for the review process.

All projects (capital and noncapital) should require a CRP. In this presentation, the term project refers to installations of new systems or equipment, relocations, renovations, or other modifications of existing systems or equipment.

The formal review process ensures facilities compliance with the following:

- Government and company workplace safety, health, quality, security, and environmental requirements, including construction and operating permits.
- Government and company building and construction codes and, where appropriate, applicable national and industrial standards.

There are two types of CRP: the full (three-phase) CRP, used for projects, and the modified CRP, used for modifications. The facility or regional safety manager along with the project engineer determines which type of CRP is appropriate for each project, based on a documented risk assessment.

Projects, Modifications, and Non-modifications

In determining which type of CRP to use, check which of these two descriptions are appropriate:

- A project (major, large, minor, or small) involves installation of new processes, systems, or equipment designed to enhance the workplace. Projects include changes to computerized systems and controls systems, installing production or process equipment, building a new facility, or any other use of corporate funds to improve the workplace. Such projects require a full (three-phase) CRP.

- Modifications to existing equipment may include installing different valve types, using new seal material, program changes, and variations in procedure. Modifications require a modified CRP.

- A nonmodification involves direct replacement of an item with an identical item (for example, installing the same design and material of seal or the same model of valve). Nonmodifications do not require a CRP.

The use of a Management of Change (MOC) checklist can be another useful tool in determining key impacts for projects and modifications. This should be used in addition to

the CRP. Factors that can sometimes be overlooked for Non-Process Safety Management (PSM) – covered companies include the following:

- Inadequate definition of change: What is replacement in kind?
- Resolution of temporary changes: Do we want to extend the duration of the change, return the process to original condition or make the change permanent?
- Managing emergency changes: How do we ensure that all requirements of normal changes are satisified?
- Procedural changes: Do we require a prestart-up safety review?
- Tracking/closure of action items: How do we verify that action items have been completed and meet the intent of the recommendation?
- Communication of the change: How do we achieve this and maintain adequate documentation?
- Prestart-up safety review- how do we decide when one is needed?

Implementation

The three phases of the project review process are as follows:

Phase I—Planning and Design Review

In this phase, the participants document all possible relevant information using the Phase I Checklist provided (reference Appendix A), workplace knowledge, and any previous CRP involvement. A list of project impacts describing general topics has been used by several companies to generate their own project review checklist (reference Appendix C), that is tailored to their unique operations and management process.

Before this project gains final acceptance, all individuals listed on the CRP Phase I Sign-Off Record Sheet, must sign off. The CRP Conditions Record Sheet, which lists conditions identified during the initial review, must be attached to each project circulated for approval. This applies to projects reviewed and approved on site as well as those sent off site for approval.

Phase II—Construction and Installation Review

The Project Engineer shall ensure this review is completed and will require all listed participants sign off the Phase II Sign off record.

The project engineer and the team members continually monitor the construction, installation, and condition of new equipment to ensure that the equipment is delivered and installed as designed. In addition, they continually audit the project installation area to ensure compliance with building codes, applicable government and company safety, health, environmental, quality and asset conservation standards, as well as site contractor safety rules.

During this time, the project engineer should resolve any issues identified during Phase I and Phase II reviews. In addition, the project engineer must manage and coordinate construction activities.

Phase III—Operational Acceptance Review

This last CRP phase includes a final project review. At this point, all of the equipment is in place, the procedures are complete, and training must occur. The primary activity in this phase is a

detailed inspection of the project to ensure that all conditions identified during the previous inspections and review phases are complete or scheduled for completion (including any certificates/permits, etc., from authorities). All noted conditions should be completed or scheduled for completion using the sites preferred risk assessment method, as a basis for assigning priorities.

Project final acceptance requires sign-off by all individuals noted on the CRP Phase III Sign-Off Record (reference Appendix B).

Always allow sufficient extra time to judge project/modification success before completing the final sign-off.

Signing Off Each Phase
Project review process sign-offs are either conditional or unconditional:

Conditional—A conditional approval means that, after reviewing this phase of the project, the project engineer or any other participant has one or more concerns about the design or installation's health, safety, security, environmental, quality or asset conservation Each condition or concern must be recorded on the CRP Condition Record Sheet (reference Appendix C). The record should clearly describe the condition or concern as well as possible solutions. It should also include the name of the individual who will follow up on the condition and a target date for closing the item.

Unconditional—an unconditional approval means all participants have reviewed the project and have no design or installation concerns regarding health, safety, security, environmental, quality or asset conservation.

All projects and modifications should be reviewed and approved using the CRP process and forms. Multiple sets of forms are recommended for each project segment or major piece of equipment.

Participants

When work requires a CRP, participants review and sign off on the project. The document can be electronically formatted for this purpose. The following table explains the three-phase CRP process and the specific individuals who must review the project or modification, comment, and/or sign off. Additional individuals can be included in any phase of the CRP as requested by the safety manager or project engineer.

Phase I **Engineering and Design Review**	**Phase II** **Construction and Installation Review**	**Phase III** **Operational Acceptance Review**
Project engineer	Project engineer	
Operations manager	Operations manager	Project engineer
Safety manager	Safety manager	Operations manager
Quality manager	Quality manager	Safety manager
Reliability engineer	Reliability engineer	Quality manager
		Reliability engineer

Figure 1. Project Participants

Risk Assessment

A risk ranking system should be adopted so that priorities can be established. Prioritizing risks gives management the knowledge to appropriately allocate resources. Each of the three project review process phases should include the use of formal risk assessment. The project engineer may use the any formalized risk assessment format that meets local regulatory requirements. The project engineer should contact the site facility or regional safety manager for details on the type of risk assessment that is used at the site. The results of all risk assessments should be maintained as part of the CRP file.

CRP Document Retention

All documents, including a hard copy of the signed CRP sign-off sheets, should be maintained and retained as part of the permanent project reference file, in accordance with site procedures, and policies for document retention.

Lessons Learned

The following list represents past experience "insights" that can prevent weaknesses in project execution and implementation.

- Understanding and managing the risks from pre-conceptual start
- Unknowns are usually risks
- Anticipate that things can go wrong
- Risk identification and quantification is the most critical step
- Risk tracking and follow up analysis are usually ignored but are the real keys steps to success
- Management commitment and buy-in is essential for success

Conclusion

In summary a project will always have risk. Projects without risk are like ships in a harbor. They're safe, but that's not what ships are built for. The difference between a successful and unsuccessful project review is the difference between trying to implement controls reactively, one by one, as opposed to developing a strategic comprehensive project review process. There are numerous programs and methodologies available for companies to manage the inherent risks of a project. The CRP is a process that provides the necessary framework to ensure risks are identified and prioritized, and information is communicated through the various stages of a project.

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Appendix A
Phase I Checklist

General Considerations

- ☐ Review all relevant governmental requirements (legislation, regulations, etc.) and codes of practice, national consensus standards, company standards, etc.
  - ☐ Review should be made with insurance broker and/or property loss control consultant depending on the expected total cost.
- ☐ Does the project present any special fire hazards?
  - ☐ Storage/staging of materials, fuel supplies
  - ☐ Hydraulic equipment
  - ☐ Ammonia refrigeration
  - ☐ Combustible oils, flammable liquids
  - ☐ Battery charging, combustible dusts, fuel-fired equipment
  - ☐ Cooling tunnels, cable trays
  - ☐ Molding line enclosures
  - ☐ Data-processing rooms
  - ☐ Laboratories
  - ☐ High-intensity discharge (HID)
  - ☐ Lighting systems
  - ☐ Ovens, dryers
  - ☐ Roasters, fryers
  - ☐ Plastics in construction or equipment
  - ☐ Warehousing
- ☐ Site-specific natural hazards (flood, wind, earthquake, etc.)
- ☐ Have local building and fire code requirements been researched and a permit applied for, if required? **(**Apply for necessary permits early in the project timeline. Approval often requires 90 to 120 days.)
- ☐ Review all environmental operating permits, pollution control systems, and other environmental management systems within the context of the new project. **(**Apply for necessary construction permits early in the project timeline. Approval often requires 90 to 120 days.)
- ☐ Identify alternative ways of satisfying the applicable pollution prevention and control requirements and working toward the goal of minimizing emissions to air, water, and land.
- ☐ Determine discharge impact on public water treatment facility. Consult the affected facility regarding proposed construction, physical alterations, and new discharges.
- ☐ Are the existing water pollution control systems (including the site wastewater treatment plant) adequate to accommodate the project?

 Will energy usage be minimized through efficient equipment, control systems and insulation?

 Asbestos-containing materials (Asbestos CM or lead-based paints (LBP): Do not use Asbestos CM or LBP in new construction. Check for the presence of any Asbestos CM or LBP in existing facilities (plant and equipment) before initiating any activities (construction, renovation, demolition, etc.) that might disturb the substances. Plan early for remediation, if necessary.

Property Loss Control Considerations

 Do emergency exit systems meet corporate safety standards and government requirements?

 Do any necessary access control emergency exit doors meet government requirements?

 Does installing new fire protection systems require revisions to existing plant fire equipment inspection, testing, and maintenance programs?

 Are automatic sprinklers provided?

 Are fire-protection water supplies sufficient to meet anticipated sprinkler system and hose pressure and flow rate demands?

 Is the required manual fire protection provided, consisting of the following:

 Fire hoses provided throughout the building
 Small-diameter fire hoses provided for storage areas
 Fire extinguishers provided as required by local codes

 Are noncombustible building materials specified? Are building materials appropriately listed/approved?

 Do structural loading, including roof and walls, meet building code and other recognized technical requirements (i.e. FM Global Data Sheets)?

 Does building code or any applicable insurance guidelines require fire-rated construction?

 Are area separation, occupancy separation, and isolation of incidental or hazardous operations and/or materials needed?

 Have surface combustion characteristics of finish materials (ceiling tiles, wall coverings, and floor coverings, etc.) been identified?

 Does the building require smoke ventilation?

 Do heating and ventilation units require smoke detection?

 Is the roof system, including structural and outer insulation membrane assemblies, designed to meet required fire and wind uplift resistance?

 Is a combustible dust being used in the process?

Environmental Considerations

 Does lighting meet current the recognized standards for lumen levels, color, etc., as required for specific areas? Major upgrades or alterations must include upgrade costs.

o Are energy efficient lights being used?

 New machine installations should specify that no single machine have noise levels above OSHA limits.

 Is storage for all environmentally sensitive materials designed and constructed to contain spills (through the use of pits, secondary containment, double-skinned containers, etc.)? Incompatible materials must be stored separately.

 Will the project require a new or modified spill prevention, control, and countermeasure plan?

 Will the project use or generate large quantities of hazardous chemicals?

 How will the project affect the site's overall waste stream?

 Conduct a chemical hazard review and risk assessment (for example, HAZOP, MSDS) for any process involving (using or generating) significant quantities of a hazardous chemical

 Will the project require a new or modified mandatory pollution prevention plan?

 Are odor control measures required?

 Identify and quantify all new or modified waste types (including hazardous waste) that may be generated and determine applicable legal requirements and disposal costs.

 Does the new waste stream require a special waste permit or certification?

 Does the project influences water use or wastewater quality and quantity?

Safety Considerations

 Workstation design provides necessary supports (for example, visibility, access, comfort, efficiency)

 Ergonomics—which, if any, of the following ergonomic considerations are associated with the project:

 Does the project introduce new manual lifting?

 How much will be manually lifted and how often will the lift occur?

 Could lift tables or other lifting assists provide support?

 Are computers included in the project? How do they fit into the workplace?

 Does the project include standing tasks?

 Are workstations equipped with footrests and anti-fatigue mats?

 Are overhead lifts required manual tasks?

 Has the corporate ergonomic consulting resource been contacted to review the project?

 Are walking and working surfaces nonslip compatible with ingredients and area cleaning?

 Are stairs installed wherever associates will be required to carry items up and down? (Stairs must be designed and installed with a 30–50-degree slope. A 45-degree slope is preferred.)

 Are drains provided for wet areas? (Floors must be properly sloped to drains (25mm per 300mm/1 inch per foot nominal). All drains should be designed with removable catch baskets.

 Is headway clearance high enough for safe passage?

 Are aisles wide enough for lifts with a standard pallet load and to allow for their maneuverability, including around corners?

 Have workplace transport and pedestrians been segregated? (This includes people, reversing trucks, etc.).

 Material approval request form must be completed and approval obtained before any hazardous material is brought on site (including for trial purposes).

 Has proper chemical storage, handling, and use been provided for?

 Will the project require the introduction of any new personal protective equipment (PPE)?

 Have eyewash and showers stations been provided where necessary?

 Has fall protection been provided for equipment at height for operational or reliability access.

 Confined Space Hazards—Are any of the following confined space considerations associated with the project:

 Does the project have any confined spaces associated with it?

 Have anchor points and access equipment provided for entry?

 Has provision for labeling each confined space been included in the project?

 Has the site confined-space inventory been updated to include all new confined spaces?

 Have individuals who will enter any confined space been trained in proper confined-space entry?

 Have provisions for eliminating hazards from the confined spaces been incorporated into the design (for example, ease of lockout, ease of venting, sufficient number of lockable valves, etc.)?

 Energy Control (Lockout)—Does the project entail any of the following energy control considerations?

 Is new equipment being introduced as part of the project?

 Are all energy sources being installed adjacent to each other?

 Are all energy sources labeled in accordance with the site's energy control policy?

 Have the written lockout and minor intervention instructions been developed for all new processes and equipment?

 Does the site have all special lockout equipment necessary for adequate energy control?

 Have all required employees been trained in how to lock out any new equipment?

 Are the air valves lockable and installed with plant standard identification tags?

 Has the corporate HEC standard been consulted to ensure compliance with the standard?

 Machine Guarding- Does the project entail any of the following machinery guarding considerations?

☐ Has the guarding included by the equipment supplier been reviewed for effectiveness?

☐ Has the corporate Machinery Safety standard been consulted to ensure that the appropriate type of interlock and safety circuit has been used for the equipment?

☐ Have the corporate standards for Palletizers, Robotics, and Machinery Guarding been reviewed for application?

☐ Does all interlocking to meet the corporate standard?

☐ Are any minor interventions associated with the equipment? If yes, does the equipment have the required two control circuit devices to protect the associates performing a minor intervention?

☐ Are all machinery drives, elevators, etc., guarded to a height that cannot be reached during normal operations (including where ladders/step ladders are provided for other normal needs of the area?)

☐ Do the guards extend down to stop people climbing under them into the danger zone (150mm/6 inches from the floor)?

☐ Is full-body access into guarded areas required for minor intervention?

☐ Is keyed access required?

☐ Are all gears, sprockets, pulleys, flywheels, shafts, etc., guarded?

☐ Are all pinch points guarded?

☐ Are all sharp edges, trip hazards, or protruding parts guarded?

☐ Is equipment accessible for maintenance activities?

☐ New machine installations should specify that no single machine should have noise levels above OSHA limits.

☐ Does the equipment have a radiation source (ionizing and/or nonionizing)?

☐ Does the equipment have hot surfaces, such as hot glue, steam pipes, etc.?

☐ Will the project require the installation of new MCC panels? If yes, who will be responsible for conducting the Arc Flash analysis of the system and labeling the equipment?

Quality Considerations

☐ Has the Quality Control assessment been followed?

☐ Are targets for right first time/waste/recycling being met?

Security Considerations

☐ Will the project affect the security perimeter established for the site

☐ Will additional security officers be required during construction?

☐ Will the project include moving doors that will require relocation or additional security access points?

Note: Any checked item denotes a discrepancy and should be noted as a condition on the Conditions Record Sheet.

Appendix B

Comprehensive Review Process Phase I—Planning & Design Review Sign Off Record Sheet

Project Title: _____Project Number: _____

Description of Project: _____

Project Engineer's Name: _____

In this phase, the participants assemble as much information as possible using the checklists provided knowledge of the workplace, from R&D, and previous CRP assessments. The CRP must be completed and signed off by all required parties when the project is submitted for approval. The CRP Conditions Record Sheet, which lists conditions identified during the initial review, MUST be attached to all projects circulated for approval. This applies to projects reviewed and approved on site as well as those sent off site for approval.

Instructions: All approvals require the signature of the designated team member. Each signature certifies that all tasks within his/her area of responsibility have been fully completed subject to any conditions noted below and described on the attached "Conditions/Recommendations Sheet." Circle either "C" for conditional approval or "U" for unconditional approval for each applicable phase.

Project Engineer: _____C / U Date: _____

Operations Manager: _____C / U Date: _____

Quality Manager:_____C / U Date: _____

Safety Manager: _____C / U Date: _____

Reliability Engineer: _____ C / U Date: _____

Appendix C – Project Impacts to Consider

DESIGN

□ Complex Design Features
□ Numerous or Unclear Assumptions or Bases
□ Reliability
□ Inspectability
□ Maintainability
□ Availability
□ Errors and Omissions in Design

REGULATORY & ENVIRONMENTAL

□ Environmental Impact Statement Req'd. (EIS) □ Additional Releases □ Undefined Disposal Methods □ Permitting □ State Inspections □ Order Compliance □ Regulatory Oversight

RESOURCE/CONDITIONS

□ Material/Equipment Availability □ Special Resources Required □ Existing Utilities Above and Underground □ Support Services Availability □ Geological Conditions □ Temporary Resources (Power, Lights, Water, etc.) □ Resources Not Available □ Construction Complexities

- Transportation
- Critical Lifts
- Population Density

□ Personnel Training & Qualifications
□ Tools, Equipment, Controls & Availability
□ Experience with system/component (design, operation, maintenance)
□ Work Force Logistics
□ Training
□ Research and Development Support
□ Multiple project/Facility Interface
□ Facility Work Control Priorities
□ Lockout Support

SAFEGUARDS & SECURITY

□ Classified process, information

TECHNOLOGY

□ New Technology □ Existing Technology Modified □ New Application of Existing Technology □ Unknown or Unclear Technology

PROCUREMENT

□ Procurement Strategy
□ First-use Subcontractor/Vendor □ Vendor Support

CONSTRUCTION STRATEGY

□ Turnover/Start-up Strategy □ Direct Hire/Subcontract □ Design Change Package Issues

TESTING

□ Construction
□ Maintenance
□ Operability
□ Facility Startup □ System Startup

SAFETY

□ Fire Watch
□ Exposure Contamination Potential □ Authorization Basis Impact
□ Hazardous Material Involved
□ Emergency Preparedness
□ Safeguards & Security
□ Confinement Strategies

INTERFACES

□ Multiple Agencies, Contractors
□ Special Work Control/Work Authorization Procedures
□ Multiple Customers
□ Co-Occupancy
□ Outage Requirements
□ Multiple Systems
□ Radiological Conditions (Current and Future) -Contamination -Radiation
□ Multiple Projects

MANAGEMENT

□ Undefined, Incomplete, Unclear Functions or Requirements
□ Complex Design Features
□ Numerous or Unclear Assumptions or Bases
□ Reliability
□ Inspectability
□ Maintainability
□ Availability
□ Errors and Omissions in Design

REGULATORY & ENVIRONMENTAL

RESOURCE/CONDITIONS

□ Material/Equipment Availability □ Special Resources Required □ Existing Utilities Above and Underground □ Support Services Availability □ Geological Conditions □ Temporary Resources (Power, Lights, Water, etc.) □ Resources Not Available □ Construction Complexities

□ Personnel Training & Qualifications
□ Tools, Equipment, Controls & Availability
□ Experience with system/component (design, operation, maintenance)
□ Work Force Logistics
□ Training
□ Research and Development Support
□ Multiple project/Facility Interface
□ Facility Work Control Priorities
□ Lockout Support

TECHNOLOGY

□ New Technology □ Existing Technology Modified □ New Application of Existing Technology □ Unknown or Unclear Technology