Making the Transition from Startup to Normal Operations

A startup plan helps ensure safe operation

By C. Keith Stalnaker

AFTER WORKING FOR MONTHS, the team of operations, maintenance, engineering and SH&E professionals that has taken an activity from design to the completion of construction is ready for a rest. The equipment has been specified, delivered and installed. Job hazards have been analyzed, engineering controls defined and implemented, administrative and procedural controls established, and workers and supervisors trained. Time for the safety professional to start thinking about the next project? No, not yet. An important phase of the new activity remains: the transition period between startup and normal operations.

This article reviews actions that an SH&E professional should consider during the startup phase of a new activity. Although application to industrial and chemical processes is described, the concepts of startup planning apply to all types of operations, facilities and equipment. The extent of startup control and planning needed is partially determined by the potential hazards and investment risk attributable to an unsuccessful startup. Even a relatively simple operation may need startup controls when inexperienced personnel or new procedures are involved. The need for formal startup planning increases when hazards to workers, the public and facilities are significant, and when financial, public relations and regulator response costs of a failed startup are unacceptable. The same concepts apply to restarting an existing activity that has been idle for an extended period.

Equipment failure, human error and electrical failure are some accident classifications used by industry (Flynn and Theodore 179). Fires, explosions, toxic emissions, hazardous materials releases and human injuries may be the result. Although accidents may occur at any time, the probability increases during initial activity operations. During startup, equipment may be unproven, workers and supervisors may be inexperienced using the equipment, and operating procedures may not be optimal. These and other reasons justify development of a startup plan that defines and imposes controls on initial activity operations. Only after personnel and equipment performance are demonstrated and uncertainties are reduced to an acceptable level can startup controls be discontinued and normal operations authorized. Figure 1 provides several real-world examples of problems experienced during startup activities that were not adequately planned and controlled.

Phases of a New Activity

A new activity (facility, equipment system or process system) typically progresses through four phases before reaching normal operations:

Phase I: Design
Phase II: Construction and testing
Phase III: Operational preparations
Phase IV: Startup
Phase V: Normal operations

Some phases may overlap. For example, preparation of operating procedures and training often occur

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while a facility is undergoing system testing. Although the safety professional must be involved in each phase, participation in activities between startup (the time when the equipment is ready to operate and operational preparations have been completed) and normal operations is crucial. During this period, the SH&E professional helps determine whether the activity is ready to operate, and whether equipment and personnel have performed as expected. It is also during this period that extra or compensatory controls may be needed to monitor activity startup and evaluate the safety of initial operations.

Processes subject to OSHA process safety management (PSM) and EPA risk management program (RMP) requirements must also have a prestartup safety review (PSSR). A PSSR is not a substitute for activities in a startup plan. It authorizes startup activities to begin, and ensures that process design and construction meet specifications, procedures are in place, training is complete and that a process hazard analysis has been performed (new facilities). The startup plan establishes compensatory controls and restrictions during startup, and confirms equipment operability, procedure viability and operator performance before normal operations begin. Benefits of a startup plan should be considered for any new or restarted activity, not just those subject to PSM and RMP requirements.

Figure 1

Startup Problem Examples: Are Startup Controls Needed?

February 1999: Pennsylvania
During preparation of the first commercial batch of hydroxylamine (HA) in a new production facility, a process vessel exploded, resulting in the deaths of five persons and damage to 10 buildings in an industrial park. Property damage was estimated at $3.5 to $4 million. The specific events leading to the incident were not determined, although several potential causes were identified (CSB Case Study No. 1999-13-C-PA).

May 1999: South Carolina
A new continuous air monitor was being tested on a line from a high-level radioactive waste tank. The tank's exhaust filter had previously failed its HEPA test. Although a portable HEPA-filtered ventilation system had been installed, a test crew removed it when performing startup activities. The job stopped when the test crew almost operated the ventilation system with the failed HEPA filters. Subsequent review indicated that the startup crew prejob briefing was inadequate. Some personnel involved were not present and the briefing focused on startup testing of a second tank that was not impacted by the failed HEPA system (U.S. DOE Summary 99-21).

July 1999: South Carolina
Following modifications to an air compressor cooling system, a worker performing startup testing replaced fuses in a 208V control panel, installed electrical jumpers and lifted motor leads without lockout/tagout protection. The startup was suspended and subsequent investigation indicated that the actions violated electrical safety procedures. Fortunately, the worker was not injured (U.S. DOE Summary 99-30).

October 2001: California
Restart of an oil refinery catalytic cracking unit was impacted when startup problems released chemical pollution to the atmosphere, resulting in temporary closure of an interstate highway. When workers heated a reactor they thought had been drained of petroleum, a release occurred. Officials concluded that startup instructions and procedures were inadequate (CSB Incident Report No. 2001-5272).

November 2001: California
A release of 84 lbs. of sulfur trioxide during plant startup resulted in community shelter-in-place warnings. Investigation revealed that inadequate training, inadequate startup procedures and insufficient backup systems were causes of the release. As a result, the company instituted a policy that requires a manager to oversee all plant startups (CSB Incident Report No. 2001-5319).

Startup Plan

Startup controls are specified in a startup plan that defines steps and actions to be taken prior to achieving normal operations. The plan details implementation of compensatory measures by management, technical, support and facility personnel during the startup phase. It defines criteria that allow the activity owner to demonstrate the ability to move from controlled to normal operations. Figure 2 shows a simple startup plan for processing pyrophoric metal fines.

The startup plan should be specific to a given activity. It may be simple or complex depending on activity scope, complexity and hazards involved. When limited operational experience exists, an increased level of initial rigor is needed to validate operational planning and preparations. Other startups require no more than defining the number of times the activity is observed under increased supervision. Startup plans may establish hold points, decision points, dry runs and inspections, or define critical performance that must be demonstrated. In all cases, the ultimate goal is to ensure safe operation before management authorizes normal operations. Other goals include confirming equipment operability, procedure adequacy and personnel performance (U.S. DOE Appendix 3).

Startup Plan Development Guidelines

Assemble a Team to Prepare the Plan

The plan should be developed by a team led by the line manager who will be responsible for normal operation of the activity. Depending on activity complexity, the team should include process and design engineers, maintenance, SH&E, line supervisors and operators. Management may need to provide guidance on plan content and format expectations. Figure 2 is an example of a simple startup plan.

Specify the Conditions of Controlled Operations

Various compensatory controls may be needed during startup. The following list does not include all such controls, and those actually imposed will depend on the activity in question. Most startup plans will not need to include all the example controls listed here.

1) **Management oversight during initial equipment use.** "For the first three runs, the operations manager will observe activities at the control panel while the organization manager observes the per-

Figure 2

Example of a Simple Startup Plan

Startup Plan for Processing Pyrophoric Metal Fines in Building A345

Approved by: *R.G. Bolden, Director of Operations, March 12, 2002*

Oversight team: Building A345 process engineer, J.R. Capston; Building A345 operations manager, M.K. Smith; safety engineer, R.T. Cline

The oversight team shall perform the following oversight activities during use of surrogate material three times prior to introduction of pyrophoric material in the processing equipment.

A) The operations manager shall verify:
- The correct operating procedure is at the work site.
- The supervisor has verified that the assigned operators (Allen and Jones) are trained on Procedure 54-098, *Pyrophoric Metal Fines Processing*.
- The supervisor conducted an adequate prejob briefing.
- The activity was performed in accordance with Procedure 54-098.
- The supervisor conducted an adequate postjob briefing.
- The work area was cleaned and hand tools were properly stored.

Initials of operations manager: Run 1 ____ Run 2 ____ Run 3 ____

B) The process engineer shall verify:
- The supervisor has verified equipment calibrations and preventive maintenance are current.
- The process equipment operated as expected.
- The materials handling equipment operated as expected.
- The temperature of bearing B-012 did not increase by more than 25°F during operations.

Initials of process engineer: Run 1 ____ Run 2 ____ Run 3 ____

C) The safety engineer shall verify:
- The supervisor and operators complied with the controls defined in the job hazard analysis.
- The operators used the personal protective equipment listed in Procedure 54-098.
- No unsafe actions were observed.

Initials of safety engineer: Run 1 ____ Run 2 ____ Run 3 ____

Activity is approved for normal operation. Compensatory actions defined above may be terminated.

_____ _____

R.G. Bolden, Director of Operations **Date**

formance of the chemical operator who loads the furnace." *Purpose: Verify personnel readiness.*

2) **Technical oversight to ensure that expected process boundaries are not exceeded.** "Following completion of step A.13.b, the process engineer will monitor the pressure rise on pressure indicator 123 of the new steam generation system. If the pressure exceeds 150 psig, then startup activities will be terminated until causes are determined and appropriate process controls established. If the pressure does not exceed 150 psig, then the startup activity may continue." *Purpose: Define who will monitor critical safety-related parameters.*

3) **SH&E oversight of the effectiveness of safety and health controls.** "Prior to starting the vacuum pump, an industrial hygienist will take air samples at three designated locations in the work area. Sampling results above 15 ppm for chemical YY will cause startup operations to be stopped until reasons are identified and corrective actions implemented." *Purpose: Ensure that equipment containment exists.*

4) **Facility supervisory oversight and evaluation of equipment operation training.** "Supervisor will perform the first use of the abrasive saw. The supervisor will verify saw controls function as explained and demonstrated during training conducted by ABC Corp., the saw supplier. Subsequently, the supervisor will observe each of the two trained mechanics use the saw to cut part XYZ at least three times." *Purpose: Verify that training is adequate to prepare personnel for operations.*

5) **Oversight by training representatives to complete personnel qualification requirements.** "Training manager will observe each trainee successfully use the lathe at least two times prior to final approval of each machinist's qualification. Trainees will not participate in first-use evolutions." *Purpose: Approve qualification based on performance during actual operational conditions.*

6) **Access controls during startup.** "Access to the operating area will be limited during startup. No maintenance, training or nonessential work will be performed." *Purpose: Limit distractions to the operators performing the startup.*

7) **Use of surrogate materials or mock-up parts during startup.** "Surrogate material will be used twice to demonstrate equipment operation prior to introducing more-hazardous production chemicals in the process system." *Purpose: Use nonhazardous materials to ensure adequate equipment performance prior to introducing hazardous materials.*

8) **Have procedures writers available during startup.** "The procedures writer and technical authority shall be present during initial use of Procedure 789. Needed improvements will be made prior to next procedure use." *Purpose: Verify that the procedure is accurate and adequate, and expedite any needed revision.*

9) **Use dry runs to prepare workers for real operations.** "The facility will successfully complete three dry runs prior to the introduction of production materials." *Purpose: Give facility personnel practice before actual production materials are introduced.*

10) **Conduct pre- and postjob briefings.** "Prior to each run, the involved operators will attend a prejob briefing held by their supervisor to review critical job steps. After job completion, the operators and

supervisor will attend a postjob briefing held by the process engineer to capture lessons learned and to identify opportunities for procedure improvement." *Purpose: Encourage personnel to give feedback and suggestions for improving operations.*

11) **Conduct valve and electrical alignments.** "Prior to starting the process, the operators will perform alignments and document results on the prepared check sheets." *Purpose: Ensure that equipment is configured as defined in operating procedures, and component labels are consistent with the alignment check sheets.*

12) **Identify tests and acceptance criteria that will be used to confirm the operability of critical equipment or systems.** "After five pressure cycles, the longitudinal weld in Part ZZ will be radiographed to verify that no cracks have developed." *Purpose: Ensure critical equipment integrity following initial use.*

13) **Design drawings have been completed, documented and are available for operations and maintenance use.** "The design engineer will walk down the equipment to verify that the equipment configuration agrees with as-built drawings." *Purpose: Ensure that engineering information supports configuration management and future preventive and corrective maintenance.*

14) **Preventive and corrective maintenance on activity equipment and facilities is current.** "The maintenance manager will verify that all corrective maintenance has been completed and that calibrated equipment is in the appropriate recall program." *Purpose: Make sure the facility will operate without unexpected equipment failures.*

15) **Testing of new equipment and systems.** "The mechanical inspector will verify that testing has been completed and results meet engineering requirements." *Purpose: Ensure that equipment and systems meet test requirements.*

16) **Notification of regulators.** Startup of some activities may require that regulators be notified or that data collection be conducted to meet environmental permit requirements. "The manager will notify the environmental compliance officer before the operations begin." *Purpose: Make sure environmental permit conditions of operation are met.*

Specify Prerequisites Important to Achieving Normal Operations

Readiness often depends on equipment and systems beyond those represented by the activity itself. Systems and equipment on which the activity depends must be operational and reliable before compensatory control operations are lifted. Utility and support systems must be able to support safe operation of the activity in normal and abnormal situations.

Define the Endpoint of Controlled Operations

The plan should clearly define when the activity may move from controlled startup to normal operations. Some operations may need to be demonstrated several times with no or few problems. The decision to begin normal operations should be based on clearly defined criteria in the startup plan. In the Figure 2 example, the decision to proceed to normal operations will be made by the director of operations. S/He will use data entered on the startup plan report to verify that the process has been operated successfully at least three times under controlled conditions, and that oversight activities assigned to relevant personnel have been completed. When satisfied that these actions are complete and adequate, s/he will sign the plan report to authorize the end of controlled operations and the initiation of normal operations.

Designate the Startup Authority

The person or persons responsible for approving the end of controlled operations and the start of normal operations should be specified. This is usually a senior representative of the organization that will operate the activity. At a point designated in the plan, this person must be satisfied that compensatory controls are no longer needed and that the activity can be operated safely with normal operational controls. Before approving the termination of compensatory controls and the start of normal operations, this person may want to meet with line management and those who monitored startup to discuss the startup report and to ask questions. Requiring formal approval encourages the responsible manager to carefully consider operational readiness.

Define Documentation Requirements

Satisfactory completion of startup plan requirements can be documented in a number of ways ranging from informal to checklists to formal reports. Documentation formality often increases when data collection is needed to support the approval of normal operations.

The startup plan should clearly define those compensatory measures necessary while activities proceed from controlled to normal operations.

Conclusion

Regardless of how good the design and how much preparation effort has been expended, a missing or poorly planned startup can delay or negatively impact a new activity. Use of compensatory controls can help prevent accidents during startup and help improve the quality of normal operations. A properly developed and executed startup plan helps ensure the long-term success and safe operation of a new or restarted activity. ■

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