METALLURGICAL PLANT COMMISSIONING— ARE THERE ANY SHORTCUTS?

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ABSTRACT

During the final stages of metallurgical plant construction there is tremendous pressure to commence production. More often than not, there will have been budget overruns and schedule delays. Corporate management and investors are naturally anxious to generate cash flow. This pressure may evolve into a *fast-track* culture regarding the commissioning and start-up. We have been involved in metallurgical plant start-ups for over 30 years, and we can unequivocally say: There is no *fast-track* shortcut to a successful start-up.

The secret to an excellent start-up includes:

- Detailed planning and documentation development commencing during the first stages of construction.
- Establishment of guidelines and procedures specific to the plant being started.
- Execution of preoperational and functional testing and introduction of feed in accordance with plans.
- Sufficient skilled trades and engineering personnel to solve problems as they arise.

DEFINITIONS

Performance Associates defines commissioning as *preoperational* (*cold*) *testing* and *functional* (*wet*) *testing*. *Preoperational testing* involves the testing and running of individual items of equipment. Examples include ensuring that motors rotate in the correct direction, cleaning and flushing of pipelines and vessels, megger testing of electrical equipment, checking electrical terminations, and ensuring that conveyor belts track properly.

Functional testing requires that equipment be grouped into systems, or packages. Each package is then tested as a complete system, including control loops and interlocks. During functional tests, the owner ensures that equipment in each system operates together as designed. Where applicable, water is introduced to systems at this time to ensure that pumping systems operate correctly.

Initial start-up commences with the initial introduction of feed, typically in accordance with a planned ramp-up schedule based on successfully achieving defined metrics at each ramp-up stage.

COMMISSIONING AND START-UP PLAN

The commissioning plan must be started during the initial construction phase. Ideally, a database tracking system is loaded with all process equipment, instruments, motors, and pipelines associated with the plant and its utilities. Following the loading of this information, areas and packages are defined. Then equipment, instruments, motors, and pipelines are flagged with the areas and packages to which they are assigned.

Procedures for the initial start-up are developed with special requirements associated with the first introduction of feed. For example, initial start-up procedures must account for dead beds being slowly built to prevent apron feeder damage, grinding mills must be fed carefully to ensure that liners are not damaged, and trunnion bearing temperatures must be carefully monitored as feed rates are increased.

TRACKING DATA

Performance Associates uses a menu-driven relational database to track and control the thousands of transactions that must occur to preoperationally and functionally test and start up a metallurgical plant successfully. The system contains modules to track the following:

- Defined areas and packages.
- Equipment.
- Piping.
- Instruments.
- Motors.
- Discrepancies.
- Notes (which can be flagged by equipment).

Packages represent systems that can be functionally tested as a unit, such as a fire water system, materials handling system, ball mill system, or a compressed air system.

Each of the equipment, piping, motor, and instrument modules contains fields for the necessary tests and/or functions that need to be performed during the testing phase. For instance, the equipment module contains fields for:

- Equipment number, type, and description.
- Equipment manufacturer.
- Vendor.
- Piping connected.
- Specifications confirmed.
- Mounting checked.
- Lubrication completed.
- Packing or seals installed and checked.
- Drive aligned.
- Cleaning and flushing completed.

- Rotation checked.
- Belts adjusted.
- Interlocks checked.
- Pressure checked.
- Guards installed and checked.
- All mechanical checks completed.
- All electrical checks completed.
- All instrument checks completed.
- System run-in completed.
- Vendor checks completed.
- Contractor's approval.
- Client's approval.

The other modules also contain fields for functions and tests associated with them, such as conduit, raceways, meggering, control wiring, power wiring, etc., for the motor module; supports, cleaning, pressure test, etc., for the piping module; and setting, piping check, wiring, calibration, etc., for the instrument module. Each of these modules, with the exception of piping, is also related to an item of equipment. This allows for printing out a list of all instruments and motors associated with each item of equipment.

The notes module allows for flagging an equipment item with any number of notes. These notes are entered with key words and follow-up dates. This module allows for maintaining a log of concerns, meetings, phone calls with vendors, etc., that are associated with any item of equipment.

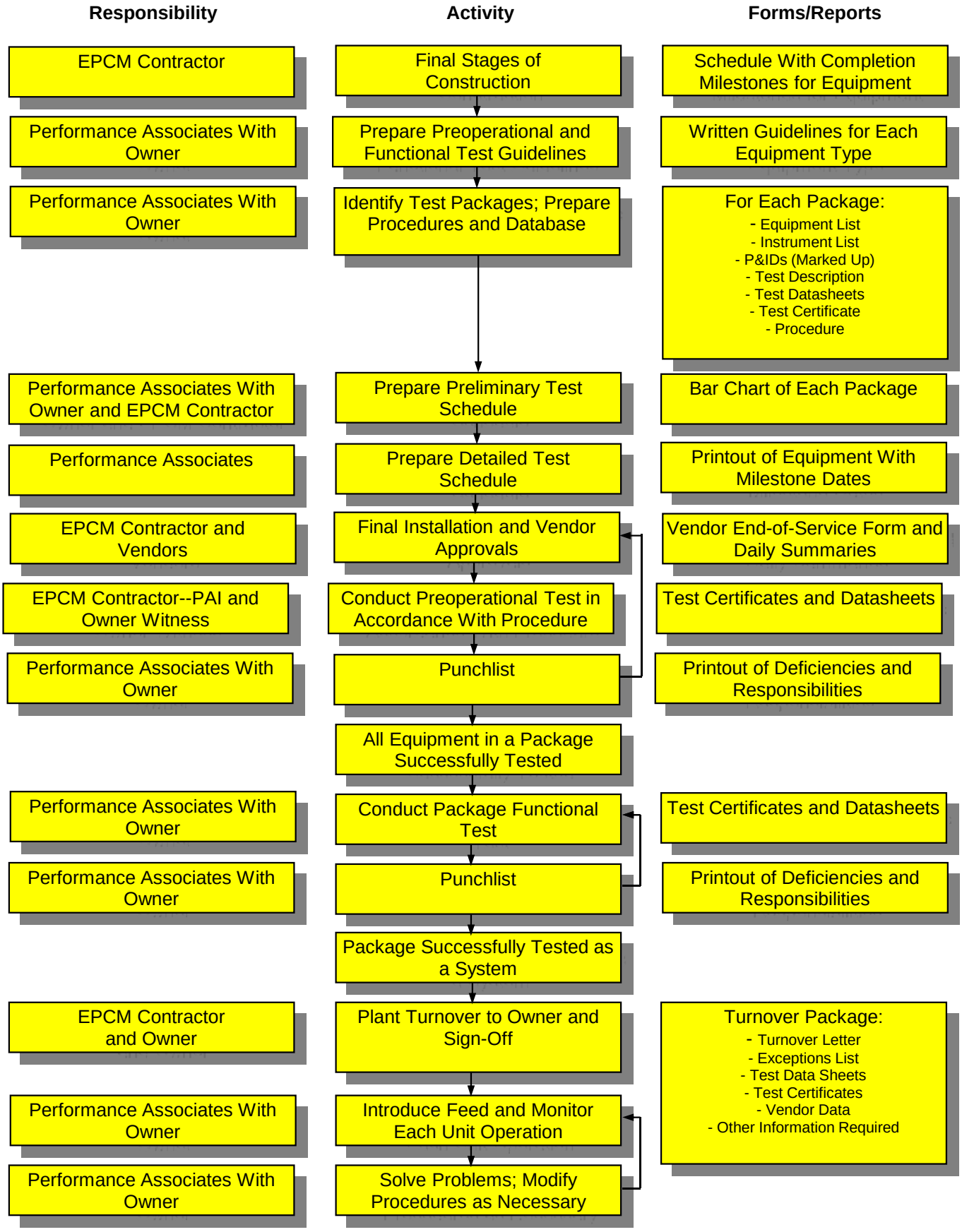
The discrepancy module allows for identifying any number of discrepancies, or punchlist items, against an item of equipment. A responsible party can then be assigned to ensure that each punchlist item is scheduled to be corrected. As discrepancies are corrected, the dates are entered. In this way, the commissioning team can control the backlog of outstanding punchlist items.

GUIDELINES AND PROCEDURES

In addition to loading the commissioning database program, test guidelines, procedures, and forms must be developed for preoperational and functional tests. These guidelines, procedures, and forms are integrated with printouts of the equipment, instruments, and pipelines associated with each test package. In addition, P&IDs showing each test package are marked up with colored markers. Finally, a test procedure and certificate are included in the test package. As construction nears completion in each area, test schedules can be refined and issued. Using the computer-based database application, individual equipment, associated instruments, and electrical items can be tested and deficiencies noted in each package.

A flowchart illustrating a typical commissioning and start-up process is attached as Figure 1.

Figure 1
Commissioning Flowchart



INITIAL START-UP PLAN

The initial start-up plan covers the initial introduction of feed following functional testing. Normally, the initial start-up plan includes the following components:

- Start-up procedures.
- Datasheets.
- Preliminary start-up schedule and ramp-up criteria.
- Start-up organization structure.

The start-up procedures include step-by-step actions required for the initial introduction of feed and milestone points where decisions are to be made on increasing feed rate to the next ramp-up rate. Criteria for the ramp-up-increase points are also included in the procedures. The datasheets provide logs for recording necessary start-up data to evaluate the condition of equipment and the process.

PLAN DEVELOPMENT

Commissioning

Development of the commissioning plan can commence as soon as P&IDs are complete and most of the equipment vendor manuals are received. The commissioning team then identifies the commissioning packages and colors them in on the P&IDs. Commissioning guidelines are prepared based on the types of equipment to be commissioned.

Following completion of the guidelines and P&ID mark-ups, the equipment, motors, instruments, and pipelines are entered into the database application. Necessary test datasheets and certificates are also prepared. Detailed procedures are developed for the preoperational and functional testing. Refer to Exhibit 1 at the end of this paper for an example procedure for a conveyor. Refer to Figure 2 on the following page for an example tertiary crusher system functional test package marked on a P&ID.

The preliminary commissioning schedule is then developed based on the commissioning requirements as defined by the equipment and packages, as well as on the construction schedule.

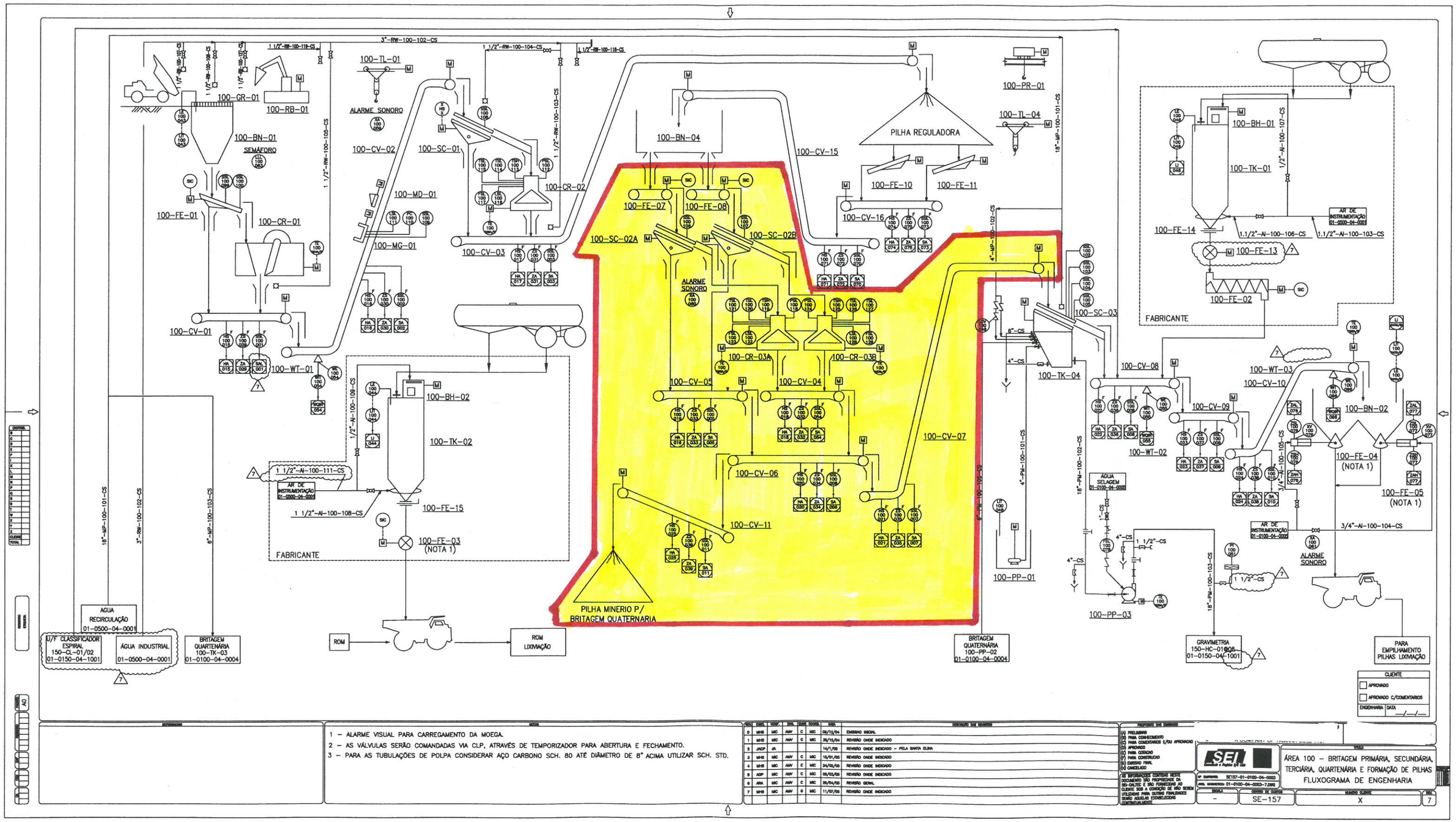
Formal meetings are conducted between the construction manager and his or her key team members and the commissioning manager and his or her team members. During these meetings, necessary coordination can be carried out, as well as dealing with scheduling issues, problems, and punchlist discrepancies as commissioning proceeds.

Initial Start-Up

Once the commissioning plan is completed, work can commence on the initial start-up plan and procedures. The initial start-up procedures can be an edited version of the routine start-up procedures developed for the operator training program. The initial start-up procedure edits are made as necessary to provide for first-time-only requirements and for ramp-up based on the decision metrics.

Figure 2

TERTIARY CRUSHING



EXECUTING THE COMMISSIONING PLAN

As preoperational testing proceeds, it is essential that appropriate test datasheets are completed as each preoperational inspection is carried out in accordance with the plan. Refer to Figure 3 below for an example of a test datasheet.

Figure 3
Example Test Datasheet

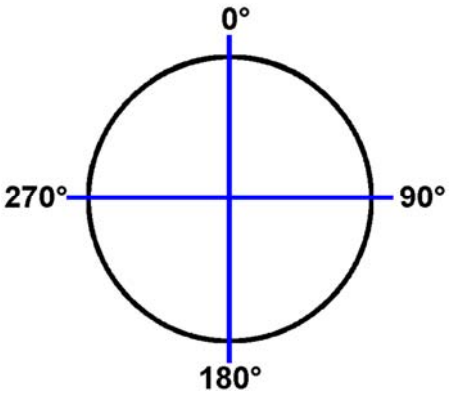
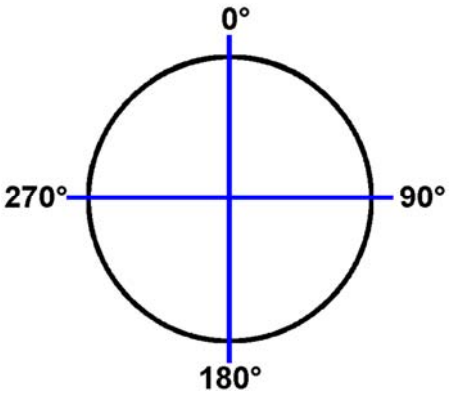
Coupling Alignment Record

EQUIPMENT NO. _____ EQUIPMENT NAME _____

COUPLING MAKE AND SIZE _____

FACE-TO-FACE DISTANCE _____

COUPLING LOCATED BETWEEN _____

DRIVER PARALLEL MISALIGNMENT (Decimals of 1 mm)	DRIVER ANGULAR MISALIGNMENT (Decimals of 1 mm)
	
0°_____ 90°_____ 180°_____ 270°_____	0°_____ 90°_____ 180°_____ 270°_____

CHECKED BY: CONTRACTOR _____ DATE _____

APPROVED BY: ENGINEERING COMPANY _____ DATE _____

APPROVED BY: PAI _____ DATE _____

APPROVED BY: OPERATIONS _____ DATE _____

Close coordination is required between the commissioning team and the construction group. Daily meetings will facilitate this coordination. Once all of the equipment is preoperationally tested in a package successfully, the package can be functionally tested as a system. During this phase all interlocks are checked and control loops are tuned. For wet systems, water can be pumped through the system to verify proper operation of seals, pumps, flowmeters, etc. Refer to Figure 4 for an example turnover letter that turns over a package to the client, ready for operations.

Figure 4
Example Turnover Letter

Date

(Name)
Project Manager
Client

Subject: Project Installation
Operable Complete Equipment
Turnover Letter No. _____
(Complete Description of Equipment, Purchase Order No. _____)

Enclosures: Attachment I—List of Operable Equipment
Attachment II—List of Exceptions

Dear _____:

The (equipment—full description) in Attachment I has been tested and inspected, and is considered to be ready for operation. Exceptions/incomplete items are listed in Attachment II of the enclosure.

Your approval is requested to inform the contractors that care, custody, and control of the equipment is transferred to CLIENT.

To indicate your approval of this completed portion of the work, please sign as indicated below and return to the undersigned, retaining a copy for your files.

NOTE: Acceptance by the client does not release the contractor from any contractual obligations.

Sincerely yours,

_____
Engineering Company, Project Engineer

_____
Contractor, Construction Manager

Approved _____Date_____
Client Project Manager

It is essential that management pressure to introduce feed early does not shortcut the carefully prepared commissioning procedures and tests. Once the plan is thrown out the "window," the start-up can rapidly spin out of control. This situation usually results in equipment damage, spills, plug ups, accidents, and an overall delay in what otherwise would have occurred if the plan were followed.

Punchlist issues are assigned to the appropriate team member for follow-up and corrective action. In some cases, minor items may be added to the operations team's maintenance department. The commissioning manager ensures that the commissioning database is updated with the latest test results and punchlist items. The database becomes the tool to track the entire commissioning effort.

Once functional testing is complete, the operations team executes the initial start-up, introducing feed and ramping up to design production in accordance with the initial start-up plan.

CONCLUSION

A comprehensive and carefully planned commissioning and initial start-up plan will provide many benefits—not the least of which is the best chance for an excellent start-up. The plan provides the opportunity to correct problems at the appropriate commissioning stage, *before* feed is introduced.

Documented test results including applicable measurements of key variables will also provide the initial records for equipment maintenance.

EXHIBIT

Exhibit 1 on the following page provides an example test procedure for a conveyor.

Exhibit 1
Example Preoperational Testing Procedure

Mechanical

----------Commissioning Tasks----------

Filename: 100_CV_11CM.DOC	**Plant Area: 100**	
Package:	Tertiary Crushing	
Equipment:	100-CV-11 – Conveyor	
Task Description:	Commissioning	
Safety:  	1. **ISOLATE, LOCKOUT/TAG, AND TEST THE EQUIPMENT BEFORE PROCEEDING WITH THE FOLLOWING COMMISSIONING TASKS.** 2. Always wear personal protective equipment (PPE). 3. For specific safety information (i.e., equipment lockout/tagout, confined space, chemicals, etc.), refer to the Company Safety Manual. 4. If in doubt about the safety associated with these commissioning tasks, consult with your supervisor before performing any of the commissioning tasks.	
References:	P&ID No. 0100-04-0003 Rev. 7	

Component/Instrument Inspection:	Task No.	Commissioning Task:	Inspected (√): Date and Initial
Drive	001	1. Check that equipment is clean and the area is tidy. 2. Check that gear reducer internals are clean. 3. Check that the input shaft turns freely. 4. Observe the first fill of lubricant. Check oil against lube spec sheet requirements. 5. Check the reservoir oil level at the sight glass or at the dipstick. 6. Check seals for oil leaks. 7. Lubricate shaft seals as required. 8. Inspect the high-speed coupling. Check that alignment specs reported on coupling sheet are within tolerance. Visually observe alignment check with instrument to verify previous work. Do not install element. 9. Inspect the low-speed coupling. Check that alignment specs reported on coupling sheet are within tolerance. Visually observe alignment check with instrument to verify previous work. Do not install element.  Coupling alignment of all skid-mounted equipment must be verified. 10. Check that gear reducer base bolts are correctly torqued. 11. Check that motor base bolts are correctly torqued.	
Pulleys and Bearings	002	1. Check pulleys for signs of damage during installation. 2. Check that pulleys are level and square with the conveyor steel. 3. Check that bearings have been lubricated. 4. Check that seals have been lubricated. 5. Ensure that bearing hold-down bolts are tight. 6. Check pulley hub bolts for tightness. 7. Before installing the belt, check to ensure that all pulleys turn freely.	

Component/Instrument Inspection:	Task No.	Commissioning Task:	Inspected (√): Date and Initial
	002	8. Check that the gravity take-up (GTU) pulley is hanging correctly within the guides and that the counterweight is not touching the ground.	
Idlers	003	1. Check that troughing, impact, and return idlers are centered and have been installed square with support steel. 2. Check that idler bolts are medium tight (so they can be adjusted as required). 3. Check that all idlers turn freely.	
Conveyor Belt	004	1. Inspect the belt for obvious signs of damage such as cut rubber or torn edges. 2. Inspect the quality of completed splice for alignment, gaps in the rubber, etc. 3. Check that belt tension is correct.	
Skirting	005	1. Check that skirting has been installed. 2. Ensure that skirting clears the belt. 3. Adjust skirting as required.	
Scrapers and Plows	006	1. Check that scrapers have been installed as required. 2. Adjust scraper tension so that the rubber lip contacts the belt squarely. 3. Check that plows have been installed correctly. 4. Check that bolts are tight.	
Feed Hopper/Dead Bed	007	1. Check that feed hopper liners have been installed. 2. Check that liner bolts are tight. 3. Check that dead bed liners have been installed. 4. Check that no structural steel or liners touch the belt.	

Component/Instrument Operation:	Task No.	Commissioning Task:	Inspected (√): Date and Initial
Conveyor System	008	1. Ensure that coupling elements have been removed and covers have been tied back. 2. Bump-start the motor to determine rotation. Ensure that motor rotation is correct. 3. Couple the motor to the gearbox and install the high-speed guard. Do not connect the low-speed coupling to the drive pulley. 4. Start the motor and gearbox. 5. Check the motor and gearbox for noise, heat, or vibration. 6. Check seals for leaks. 7. Stop the gearbox. Install coupling elements and bolt up cover. 8. Install the coupling guard. Test effectiveness. 9. Start the motor. 10. Check that the belt trains properly in the center of the idlers and pulleys. Make adjustments as required in small increments. 11. Check pulley bearings for unusual noise, heat, or vibration. 12. Check that skirting is not dragging on belt. 13. Check the scrapers. 14. Continually check the temperature of gearbox and motor.	