



Machinery and equipment damage during first start-up, testing and commissioning

A guide to loss prevention



HSB Engineering Insurance

Damage to machinery during the start-up, testing and commissioning phase of a new project continues to be a significant cause of large insurance losses. It is during the initial start-up of new machinery when any deficiencies in construction quality, plant design and manufacturing are discovered for the first time; if such problems have gone undetected during construction quality control and inspection procedures.

A guide to loss prevention

This document aims to provide general guidance and an overview of a new machinery start-up process by identifying the key elements that should be found in a well-organised Testing and Commissioning plan for the start-up of any new project.

When new plant is being brought into service for the first time following machinery erection, it is essential that the newly-erected machinery is thoroughly tested to confirm that machinery design, specification and quality of construction meets the demands imposed on the installed equipment during normal operation. Testing is also necessary to ensure control and safety systems function as expected during normal operation and beyond normal operating parameters. This process is known as Testing and Commissioning (T&C).

The process of T&C of new machinery must follow a safe and logical plan, taking the equipment from mechanical completion through to steady and full capacity operation; and subsequent acceptance/handover to the owner. If damage to the machinery is to be avoided, it is essential that this process is controlled by trained and highly-experienced engineers who have a detailed understanding of the operating parameters of the process plant that has been erected.

The T&C process must demonstrate that the machinery is complete, free from construction debris or defects, has been erected in accordance with design, and is capable of withstanding the operating parameters of the process. T&C must also demonstrate that the new machinery can be controlled and is safe to operate.

T&C, if carried out correctly, should expose any weaknesses or shortfalls in equipment design, construction or

capacity which may require correction before the machinery is handed over to the owner. It follows, therefore, that the T&C period has the greatest exposure to equipment damage and, as T&C begins on completion of the construction period, has the potential to lead to delays in final project completion and handover.

Testing and commissioning control document

During the early phase of construction, and well before the start of T&C, the contractor responsible for the project T&C should produce a written document/plan which sets out how the process of T&C is to be controlled. This document must be written specifically for the project, taking into account the particular equipment type, design, services, utilities, risks and hazards that are associated with the given project. Any experienced and responsible contractor will have a generic T&C control document already available as part of the normal corporate control documentation, which can be adapted for a specific project.

The document should set out the roles, authorities and responsibilities of the individuals appointed to form the start-up team, including an organogram. The senior manager of the start-up team should report directly to the overall manager or director of the project.

The control document should include T&C procedures which define, in detail, how every step in the T&C process is to be achieved; starting with the process of identifying Turn-Over Packages (TOPs) and concluding with handover and acceptance by the owner. The document should detail the acceptance criteria for each stage of the T&C process.

Preparation of the T&C control document should begin as soon as work on preliminary engineering designs for the project have begun, to enable design

of the project to include provisions for T&C, and the T&C procedure to incorporate the developing design of the machinery being constructed.

The T&C control document should form an integral part of the overall site safety and construction quality control procedures.

1 Organisation for testing and commissioning

Reporting and levels of authority

The senior start-up manager should have ultimate authority and control over every aspect of the T&C process, with the power to halt the T&C process at any stage if safety, machinery integrity or equipment damage is at risk. The senior start-up manager should be a person with many years of experience in the type of machinery under their control, with detailed knowledge of the machinery that is being constructed. A deputy start-up manager should also be appointed with equal authority, knowledge and experience to the senior start-up manager to take control during absence.

The senior start-up manager should have under his/her control a team of engineers, each having individual skills in the various disciplines required throughout the T&C process (electrical, mechanical, control, instrumentation, operation, documentation, planning, etc).

The senior start-up manager should chair daily meetings with the start-up team to discuss progress, issues, concerns and the work schedule for that day and the following weeks/months.

The start-up manager must also report progress, issues, concerns and future work schedule to the overall project manager or director. A section should be included in the monthly project progress report which is dedicated to start-up progress, issues, concerns and forward work schedule.

Vendor representatives

Vendors of key machinery and packaged equipment will normally provide engineers and technicians with specialist knowledge to test and commission the sections of machinery supplied by that vendor. It is essential that these vendor representatives are under the direct control of the start-up team as their knowledge of the whole plant may be limited to their specific scope of supply. Vendor representatives must work within the controlling framework of the testing and commissioning control document established by the main contractor.

Vendor representatives must be included in the daily communication process and be made aware of the overall T&C schedule and present state of progress.

Start-up schedule

A start-up schedule should be prepared early in the project and should be included in the overall project construction schedule, with sufficient time allocated for T&C. The initial project schedule may only show T&C as a single activity but, at some later date, a detailed T&C schedule is required, setting out the sequence and timing of all the individual tasks required throughout the T&C process.

If construction work is delayed and the project guaranteed completion date is challenged, the time allowed for T&C is often a target for reduction to maintain the contractually-guaranteed project completion date. This can lead to shortcuts being taken in the T&C process, and while some economies of time may be possible within the schedule, any major reductions in the time allowed for T&C should be resisted as this may pressurise the process and lead to errors; with the attendant potential for damage to the machinery.

Documentation

Early in construction, the entire plant should be divided into logical TOPs

which have clearly-defined process boundaries. These boundaries will normally be defined as the system isolation points on a series of system drawings, and each TOP should be capable of logical definition. For example, the boundaries for a compressed air utility system could be defined as 'from the compressor drive motor point of electrical isolation, and including the motor, compressor, air receivers, pipework, air dryers and the rest of the pressurised system, up to the isolation valves at the point of use'.

Before any TOP is turned over for start-up, all construction quality documentation and inspection and test records must be confirmed as being complete and to the required specifications. The installed machinery itself must also be confirmed as being physically complete. This will require a detailed documentation control and checking process to be in place. Proprietary project document control databases are available to manage this process.

For each TOP, a checklist of all of the required manufacturers' quality, test and inspection documentation should be prepared. The checklist should also include quality documentation confirming that all inspections, tests and checks have been completed during construction. Throughout the machinery delivery and construction process, these documents should be collated in dossiers specific to each TOP.

Individual documents to be included in the dossier should be checked to ensure that erection of the installed machinery meets the specified requirements, and each document should be signed off by a senior engineer. As the individual documents are collated into the TOP dossiers, they should be 'ticked off' in the document management database until the dossiers contain all of the documents required by the document checklist for the TOP.

Machinery documentation should typically include the following records and documentation (though the list is not exhaustive):

- Material composition certification
- Weld inspection and test records
- Manufacturers' fabrication, test and inspection records
- Factory acceptance test records
- Foundation test results
- Concrete formulation and crush strength test results
- Hydraulic/pneumatic test results
- Factory performance test results
- Bolt-tightening records
- Shaft alignment records
- Electrical insulation resistance test results
- Proof load test results
- Drawing and dimensional check records
- Instrument testing and calibration results
- Safety valve bench setting records
- Control loop testing results
- Control parameter set point records
- Specification of lubrication and hydraulic fluids used for first fill
- Inspection records confirming a system is clear of debris
- Motor direction of rotation records
- Leak test results
- Painting and protective coating application records
- Inspection certification confirming that fire protection systems are designed and installed to the appropriate and recognised standards
- Machinery vendor technical, operation and maintenance manuals
- A full set of as-built drawings

Until the individual equipment dossiers have been signed off as containing all of the required documentation, the TOP covered by the dossier should not be accepted for T&C by the start-up team.



Turn-Over Package (TOP)

Once erection of a TOP is considered to have been completed by the construction team, it should be offered up as complete to the start-up team and a sign-over document should be used for formal acceptance.

At this point, engineers from the start-up and construction teams should carry out a very detailed walk-down of the TOP, with the aim of confirming that the system is indeed physically complete and that every element of the TOP has been completed and installed. From this walk-down, a punch list of non-conformances and omissions found should be produced.

The punch list should be prioritised as A, B, C or D to identify items as follows:

- A** Items which prevent safe or normal operation of the machinery or present health and safety hazards for the operators. (These items must be completed before start-up can proceed.)
- B** Items which prevent safe or normal operation of the machinery and require the equipment to be shut down again at some point to allow correction. (These items must be completed before handover to the owner.)
- C** Items which do not affect safe operation of the machinery but require correction before handover to the owner.
- D** Items which can be completed after equipment handover with agreement of the owner.

Insurers expect all fire protection and detection systems to be fully operational on a TOP before start-up commences and are, therefore, considered priority 'A' items.

Once all priority 'A' items have been confirmed as complete by a further

walk-down, the TOP can be accepted by the start-up team and signed over into their control.

Order of start-up

The order in which TOPs are started up should follow the logical requirements of the process. For example, the start-up of fire pumps will require availability of a water supply and an electrical system. This requires that the electrical distribution system is energised before the fire pumps can be operated, and that the water supply line is installed. It is important that this logical sequence of system requirements is built into the construction programme from the very start of the project to enable these systems to be completed at the right time in the T&C process.

Management of change

During the start-up process, it is often necessary to change some aspect of the equipment that has been installed. This may be a permanent change to improve or correct equipment operation, or may be a temporary change to allow a specific testing procedure to progress.

Temporary changes can include the application of physical jumpers to the electrical circuitry, or alterations to the electronic process control system by a process known as 'logic-forcing' (which involves accessing the controlling logic and altering the input, output or set point parameters). These temporary changes are used to, for example, allow the brief operation of a pump to check direction of rotation before the tank from which it draws suction has been filled; which would cancel the tank low-level pump cut-out switch. By applying a jumper to the switch or forcing the control logic, the pump can be operated with an empty supply tank.

It is essential that all of these temporary changes are accessed and approved by a competent and knowledgeable engineer before they are applied, to prevent damage to the equipment.

The need for any temporary change should be requested in writing to the start-up team manager, and the implications of the change discussed and assessed. Formal approval, if given, should be confirmed by the signature of a senior member of the start-up team on the requesting document. The change should only be carried out once this approval has been given.

A log of jumpers and logic forces should be maintained in the control room, recording the date, time and details of the change and the name of the responsible engineer carrying out the change. It is essential that once the change has been restored to normal, the log entry is updated to confirm this restoration. The log should be reviewed by the senior shift engineer at the start of each shift.

Before the machinery is allowed to proceed to start-up, there should be a formal review of the status of all jumpers and logic forces to ensure that the machinery control systems are in a safe condition as designed. There should be a further review of all jumpers, logic forces and changes in operating parameters before the equipment is finally handed over to the owner.

In some instances, the original equipment manufacturer (OEM) will have on-site technicians who have exclusive access to alter local controlling logic. It is essential that these OEM technicians also follow the same procedure for controlling change.

The need for permanent changes to the machinery from the original equipment design may be required. Such changes must also be requested in writing and assessed by a senior engineer as it may be necessary to revert to the original equipment designers and require revision to drawings and a full review of how the change affects machinery operation.

Throughout the entire construction and start-up period, a record should be maintained of all changes made to the equipment from the original design scope, and each change should be formally assessed and approved before application.

Considerable damage can occur to operational machinery if temporary changes applied during start-up are not restored before the equipment is handed over to the owner.

Hot and cold testing

Hot testing and cold testing are terms used frequently by insurers and is defined in terms of the perceived increasing level of risk in passing from one phase to the next.

On a processing plant, for example, the first introduction of hazardous materials such as flammable gas, chemicals, fuel or flammable materials, may be used to determine the start of the hot testing phase. However, prior to first introduction of feed-stock, the electrical system would need to be energised and tested to allow the feed materials to be transported. This electrical system energisation and testing may be regarded as 'cold testing' as the electrical apparatus will not experience the loads imposed upon it during normal operation. There is, however, an increasing risk of equipment failure or fire from the point of first electrical energisation.

Some indication of the transition point between cold and hot testing for various types of machinery under construction are given below:

- Thermal power plant: first firing of a boiler
- Gas turbine power plant: first firing of a gas turbine
- Cement manufacturing: first firing of a kiln

- Gas processing plant: first admission of gas.
- Oil processing plant: first admission of oil
- Hydroelectric plant: first admission of water
- Chemical plant: first admission of chemicals

To mitigate the increased level of risk at the point of transition from cold to hot testing, it is essential that all fire protection systems planned for inclusion on the project site are operational in the areas where such fire risks are present.

Performance testing

Once new machinery has been commissioned and tested up to the maximum design or nameplate capacity, the owner will require evidence that the equipment can achieve the capabilities that were set out in the original contract specification. A machinery owner will not normally take ownership of the project, agree that the contract is complete or issue a provisional acceptance certificate until this capability has been fully demonstrated.



Performance testing is the normal operation of the plant but with accurate measurement of an agreed range of

parameters over a specified period, which allows overall performance of the machinery to be formally demonstrated. This will include factors such as fuel consumption relative to output, maximum and minimum capacity, environmental emissions, water consumption and demand response rates. Performance testing does not normally present a higher level of risk in comparison with normal plant operation. Satisfactory completion of performance testing normally signals the end of the construction project.

Reliability testing

Reliability testing is the normal operation of the machinery during which time a formal log is kept of the number of failures to start, equipment breakdowns, trips, process excursions, operating problems, etc.

Reliability testing may take place in parallel with performance testing or possibly after formal acceptance by the owner. The owner will hold the right under the construction contract to insist on correcting any issues which do not meet the original reliability specifications.

Reliability testing periods may vary from a few days to a few months and often occur once the machinery has begun commercial operation.

Reliability testing does not normally present a higher level of risk in comparison with normal plant operation but may require the contractor to return to site to correct any deficiencies that are found.

System flushing

Before any system is put into service, it is essential that any unwanted debris which may have entered the system during construction is removed to avoid damage. For example, bearings can be damaged by entrained particles, turbine blades can suffer impact damage from grit, welding slag and foreign objects,

filters can be blocked, control systems can be rendered inoperative by clogging with dirt and debris and pumps can be damaged by stones or foreign objects.

System flushing may involve the introduction of temporary pipework and 'finer than normal filters' into the system to ensure that adequate flow rates are achieved to remove unwanted materials; these unwanted materials are captured by the filters for removal.

System flushing may also involve high pressure steam lines supplying a steam turbine from a boiler being frequently blown out using the steam from the boiler, with temporary pipework added to bypass the turbine and divert the blasts of steam to atmosphere to avoid damage to the turbine by entrained debris. To ensure the steam is 'clean', target plates are often introduced into the steam flow to record impact damage, with the plates examined after each steam blow until any indentation marks left by welding slag and other particulates consistently fall below an acceptable level.

As steam flushing uses large volumes of high temperature steam passing through temporary pipework, it is common for scaffolding to remain in place to allow the removal of the pipework on completion of the steam-blows. However, fires have occurred where, for example, timber scaffold boards or other combustible debris have come into contact with such high temperature pipework. It is essential, therefore, that before steam blows are allowed to commence, the entire pipework route is physically walked-down and any combustible materials that might be ignited by the high temperature external walls of the pipework are removed. This is a particular concern if the temporary pipework has not been thermally insulated, as is often the case.

Where systems containing combustible fluids (such as lubricating oil) are being flushed, it is important that a close watch be maintained for leakage during the flushing process. Oil flushing should not be undertaken when an area is unmanned. Oil flushing is often carried out early in the testing and commissioning process; the risk of a large oil fire is ever present. Local area fire protection should, therefore, be available for operation, even if this is only in manual release mode.

Availability of fire protection

There are many instances in construction projects where fire protection systems have not been completed at the required time, and machinery start-up has commenced without fire protection systems being fully operational. This presents an unacceptable and avoidable risk to the equipment. Fire protection systems should be available for operation as soon as the fire risk that is being protected is present.

In practice, this means that T&C of the fire water pumping and distribution system should be at a very early stage in the overall start-up process.

Leakage and fire detection

From first introduction of a working fluid into a process, a regime of regular and detailed visual inspection should be established to detect the presence of any leaks that have somehow escaped detection during pressure testing. This is of particular importance in hidden voids, tunnels and service shafts. Water leaks have occurred from service pipework in high rise buildings, leading to significant damage to decorative finishes and electrical utilities. This is a particular problem if leakage occurs overnight or at weekends when the project site is unmanned.

Until there is a high level of confidence that systems are leak-free, pressurised systems should be isolated and left at

low or atmospheric pressure when the site is unattended.

If flammable gas systems are present which cannot be easily depressurised or vented, installed flammable gas leakage detection systems must be operational and able to alarm a monitored observation point.

Fire, heat and smoke detection systems should also be operational at the earliest possible time, particularly in electrical distribution centres and in areas where flammable or combustible materials are present. Fire detection systems should also alarm to a monitored observation point.

Training of plant operators

As a process plant nears completion, it is normal for the owner to appoint the team of operators that will run the equipment. It is also normal for the new team of operators to work with the start-up team to gain an early understanding of the new equipment; but until the machinery has been formally handed over to the owner, care and custody of the machinery remains with the contractor building the project. Thus, the new team of operators must work under the control and supervision of the start-up team.

New operators should be fully trained in operation of the equipment and have full understanding of the process that is being operated.

Clear lines of authority and communication should be established between the start-up team and the machinery operations team.

2 Designing for testing and commissioning

From the start of the design process for a new project, the requirements of T&C at the end of the project must be



considered and suitable provisions included in the initial process design.

Examples

When calculating the strength of pipeline supports, the weight of water used during hydraulic pressure testing must be taken into account, even if the pipeline does not normally carry water.

Adequate provisions must be made to drain pipelines of hydraulic test water by ensuring that drain valves are included at the low points and the lines have natural falls to allow drainage. Underground pipelines present particular problems of water drainage.

To prevent a vacuum implosion, vessels which are to be leak or hydraulically tested with water and then drained must be provided with suitable vents to allow air into the vessel while draining.

Venting of large volumes of high pressure natural or other flammable gases to atmosphere for cleaning gas pipelines should not be permitted. Flammable gas pipeline design must allow for other means of cleaning the pipeline after erection, particularly for smaller bore lines where pigging may not be possible (see NFPA 56 - Standard for Fire and Explosion Prevention During Cleaning & Purging of Flammable Gas Pipelines - 2014 Edition).

Pipelines supplying steam to turbines may be blown clean by a large number of high pressure, high velocity steam blows, vented to atmosphere via temporary pipework as explained above. The forces imposed on the pipework during these steam blows may be greater than those imposed during normal operation. Pipe supports must, therefore, be designed with these additional loads in mind. The trajectory and range of debris blown to atmosphere during steam blows must also be considered.

During cleaning and flushing operations of lubricating oil, hydraulic oil and similar systems, fine mesh 'commissioning' strainers are normally installed to trap and remove fine debris carried with the oil. The pipework design must include some means of installing and removing these fine mesh strainers and must also avoid any further introduction of debris into the system.

Performance and reliability tests may require temporary instrumentation in addition to that required for normal operation. Therefore, suitable fittings should be included in the original design to allow for installation of this temporary instrumentation. Large fires have been caused when unplanned instrumentation points have been cut into duct work when using 'hot' cutting methods.

When starting up new machinery for the first time, it can be expected that the digital control system (DCS) will have more alarm conditions displayed than would be expected during normal operation. It is important, therefore, that the method of annunciating these alarms clearly differentiates and categorises the importance of these alarms; allowing the operators to fully understand the status of the machinery. Instances have occurred during T&C where many hundreds of alarms have been generated but critical alarms have not been visible on screen due to poor design of the alarm discrimination and hierarchy system.

3 Hazard Analysis and Hazard and Operability studies

Hazard Analysis (HAZAN) and Hazard and Operability studies (HAZOP) should be carried out at an early stage in the design of a process plant. This is of particular importance for plants processing chemicals, flammable or toxic materials, or employing processes that may result in damage or harm if incorrectly operated.

The recommendations of HAZOP and HAZAN studies should be included in the design of the machinery and the HAZOP/HAZAN studies should be regularly reviewed during the construction process.

The HAZOP/HAZAN impact of any change from the original design should be assessed.

Guidance on carrying out HAZOP study is provided in IEC International Standard 61882 - Hazard and Operability Study Application Guidance.

4 Fire incident pre-planning

During the start-up process, a 'fire and emergency response plan' should be in place and coordinated with the local fire service where possible. The plan should consider potential fire scenarios and the type and level of response required.

An incident controller and designated key holder should be appointed to manage the incident from inception to conclusion.

The 'fire and emergency response plan' document should be held by the designated key holder if the site is not manned 24/7, or at the permanently manned location if the site is always occupied.

The local area fire service should be familiar with the process plant, hold a copy of the site layout plans and fire incident plan and have a list of current emergency telephone contact numbers.

5 Permit to Work systems

From the commencement of start-up activity, the start-up team should have a formal Permit to Work procedure in place to control and authorise work on the sections of machinery under their control. The procedure should include a process for isolating, and locking and

tagging (LOTO) the isolation points and for issuing a work permit document by a senior authorised person.

The Permit to Work procedure should also include a process for control of hot work (flame cutting, welding, grinding, etc) which should include the following fire prevention requirements:

- A suitable portable fire extinguisher available at the point of work.
- A fire watchman, trained in firefighting, stationed at the point of work.

- The work area to be cleared of combustible materials before work commences.

- Fire retardant sheets or blankets used to prevent sparks and hot materials falling on equipment below.

- Hot work should be carried out at least 20m from any combustible materials.

- Hoses and bottle sets should be examined and be in good condition before commencing work.

- Flammable gas bottles and torches must be maintained upright, secured in cradles and fitted with flash-back arrestors.

The work area should be examined periodically during the hour immediately after work is completed to ensure there are no smouldering or incipient fires.

Once the start-up team has taken control of a TOP, the isolation points should be locked and tagged, and barriers, tapes and notices placed around the TOP, warning that the section of machinery is 'live'. Any further work on the machinery after turn-over should be subject to a Permit to Work, strictly controlled and issued by the start-up team.



Testing and commissioning - a summary of risk control measures

Testing and commissioning of a new process plant is a period when any defects, omissions or design problems will be discovered for the first time. It is important that management of the start-up process takes into consideration the increased risk of potential equipment failure and resultant damage during this period, as well as ensuring measures are in place to control this increased risk. Recommended controls to mitigate risk are as summarised in the table opposite.

Controlling documents

A 'T&C Plan' should be developed to establish a management approach to the whole T&C process, and should include an organisational structure (including dedicated start-up team), roles, levels of authority and responsibilities of all start-up team personnel, a schedule of T&C works (including specified timeframes) and 'T&C Procedures'.

Planning and coordination

Item	Action
Schedule	The T&C schedule should be incorporated into the overall construction schedule/programme from the start of the construction project. Any compromises in the time allowed for T&C should be resisted.
Order of start-up	A logical sequence of machinery start-up should be established early in the project planning stage, and the construction schedule/programme should reflect the requirements of the start-up process.
Documentation	All inspection, test and quality documentation should be listed and collated into equipment dossiers and checked to ensure that all of the required documents are present before start-up proceeds.
Fire protection and detection	Fire protection and detection systems should be installed in accordance with design, and available for operation before start-up is allowed to proceed on any TOP.
Fire planning	A 'fire and emergency response plan' should be established in advance of any start-up, in coordination with the fire service where possible.

T&C Procedures set out how each step in the T&C process is to be achieved along with acceptance criteria, and should include the following as a minimum:

- Interfaces with design team and contractors (to ensure adequacy of design for enhanced loads applied during T&C)
- Preparation of start-up schedule, interfaces with key vendors (who provide key items of equipment)
- Management of quality control documentation (e.g. inspection and test records)

- Turn Over Packages (TOPs) and order of start-up
- Management of change (e.g. logic forcing)
- Hot and cold testing
- Performance testing/monitoring and reporting
- Reliability testing/monitoring and reporting
- System flushing processes
- Availability of fire protections during T&C

- Monitoring leakage and effective operation of gas/smoke/heat and fire detection systems
- Training of plant operators
- HAZOP/HAZAN studies and effectiveness monitoring during construction phase
- Permit to Work systems and controls
- Fire and emergency response

Terms and definitions used in this guide

Acceptance testing – A period of defined tests by the constructor to demonstrate to the owner that equipment meets the performance specifications and parameters set out in the construction contract scope. A provisional acceptance certificate (PAC) is issued on satisfactory completion of the tests.

Cold testing – Testing of individual elements of the machinery, short of full operation, to demonstrate that these elements work as designed. Typically, this may include energisation of transformers and switchgear without application of significant load, drive motor test spins to check direction of rotation, slow turning of shafts, rotors, kilns etc, hydraulic pressure testing, unloaded operation of conveyors, light loaded operation of fans, blowers, compressors, etc.

Commercial operation (COD) – The start of operation of the installed equipment by the owner for commercial benefit following provisional acceptance.

Back energisation – Energisation of the on-site electrical distribution systems from an off-site power grid connection.

Final acceptance – Acceptance of the completed project at the end of the contractual defects liability period.

First introduction of fuel or feed stock – The date on which the machinery first receives fuel or process feed into the system. This date is of particular significance if the fuel or process feed material is hazardous or combustible, requiring specific process safety and fire controls to be in place.

HAZAN (Hazard Analysis) – A structured, quantitative study to

determine what hazards are present and what measures can be taken to mitigate the risk.

HAZOP (Hazard and Operability) – A structured risk assessment technique to identify possible ways of incorrectly operating a system, the hazards this presents and the measures to be taken to mitigate the risk.

Hot testing – The period of machinery testing following first introduction of fuel or feed stock following on from cold testing. During hot testing, the installed equipment will be subject to the pressures, temperatures, flows and loads imposed during normal operation.

Jumper – Physical application of a length of electrical wiring to an electrical control circuit to defeat the operating logic (sometimes known as a trip-bypass when applied to a trip system circuit).

Logic forcing – A process of accessing the electronic computer programmes which control the machinery to alter the normal pre-set values, parameters or sequences of operation. Logic forcing is used to enable testing of equipment items when normal control signals are not yet available from the rest of the equipment.

Performance testing – A period of testing to demonstrate that the machinery can deliver the specified output within designed, statutory or customer-defined parameters, such as specific fuel consumption, emissions limits, feed stock consumption, voltage and frequency control, product quality, etc.

Provisional acceptance – The initial acceptance of the completed project by the owner from the contractor at the end of the construction period; usually indicating the start of commercial operation and the start of the contractual defects liability period.

Pressure testing – Application of hydraulic or pneumatic static pressure to a system in excess of the normal design pressure (typically 1.5 times design pressure) to prove integrity of construction.

Punch list – A prioritised list of non-conformances or construction omissions in a system that requires rectification dependant on priority.

Reliability testing – An extended period of normal machinery operation during which the reliability of the machinery is measured in respect of breakdowns, starts, stops, response, wear and tear, system fouling, etc.

System flushing – A process for removing construction debris from a system, which might otherwise damage the equipment, by causing higher than normal rates of fluid flow. Fine filters are normally used to trap debris disturbed in the process or in the case of a steam system, the debris may be blown to atmosphere.

Start-up team – A group of very experienced engineers charged with the responsibility of controlling and completing the testing and commissioning process ready for machinery handover to the owner.

Turn-Over Package (TOP) – A discreet section of the machinery which can be clearly defined from the system drawings and which can be considered as a section of machinery to be turned over to the start-up team ready for testing and commissioning.

Disclaimer: The guidance in this document refers to industry best practice loss control advice. Adoption of the advice contained within this document does not imply compliance with industry, statutory or HSBEI guidelines, nor does it guarantee that related losses will not occur.

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Notes



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