SUPPLY CHAIN QUALITY SURVEILLANCE AND RISK MANAGEMENT IN THE HYDROPOWER INDUSTRY

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Abstract: This paper is aimed at analysing the process of purchasing critical components for hydroelectric power plants, such as pressure parts, rotors, and valves, considering a Supply Chain Risk Management (SCRM) strategy, and focusing on how to minimize poor quality and its negative impact on construction time, on plant performance and on safety by means of continuous Quality Surveillance of the manufacturing process (CQSS – Continuous Quality Surveillance Scheme). Discovering poor quality at a late stage can add an exponential increase to the costs, with dreadful consequences for the client and the development of the whole plant.

1 Introduction

The process of purchasing critical components for hydroelectric power plants, such as pressure parts, rotors, and valves, can be improved by implementing a Supply Chain Risk Management (SCRM) strategy. This can be used to minimize poor quality and its negative impact on construction time, on plant performance and on safety by means of continuous Quality Surveillance during manufacturing (CQSS – Continuous Quality Surveillance Scheme).

Hydroelectric power plants have complex structures and involve large amounts of capital, with a long-running construction period. This situation imposes uncertainty factors with considerably high risks. The construction phase is identified as a critical phase in hydropower projects where many unforeseen factors occur. Failure to manage project risks leads to significant problems for the project. In order to prevent time delays and cost overruns in hydropower constructions, a project risk management in the construction stage of hydropower plant projects should be conducted.

A method known as the Continuous Quality Surveillance Scheme (CQSS) can be used to minimize poor quality once a specific Supply Chain Risk Assessment has been carried out. The CQSS philosophy requires the formalization of some main elements: the Pre-Inspection Meeting (PIM) at the start of construction to ensure that all the technical and quality aspects are understood by all the subjects involved in the project; the Inspection and Test Plan (ITP), a document for quality control defining all the inspections and tests required during the construction process; the use of Notification for Inspection (NOI), as the vendor is responsible for notifying the scheduled inspection dates to all the subjects involved. In parallel with the inspection activities, regular expediting visits can be made at a supplier's premises, to find (and help solve) potential problems that could affect construction and cause delivery delays.

2 An overview on Risk Management

Risk Management consists of three basic steps: risk identification, risk analysis and risk resolution.

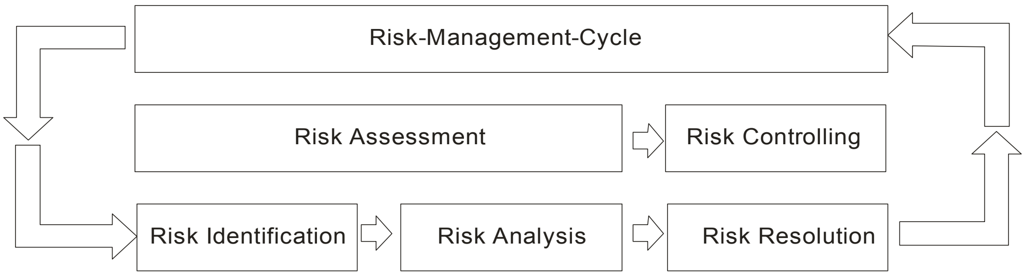

Fig. 1. Process of the Risk-Management-Cycle

2.1 Risk identification

The identification of risks is the basis for any further action. The risk identification process is sufficient when it uncovers the risks and its sources while there is time to take action [1].
There are a number of techniques which can be used to assist in the identification of risk, such as Physical inspection (involving an actual visit to the location of the risk), Fault trees (diagrammatic representations of all the events which may result in loss), or Hazard indices (techniques which express the likelihood of a loss as a number, so as to allow the comparison with other similar types of risk).

2.2 Risk analysis

After the risks are identified, they must be individually assessed as to their potential probability and consequence [2]. Following methods of risk analysis can be presented [3]:

- Intuitive approach. This is the traditional approach for accounting risk. However, the obvious disadvantage of this approach is that the estimate depends solely on subjectivity and is therefore inaccurate.
- Sensitivity analysis (probably the most common way of handling project risk in practice).
- Statistical methods, for example, probable risk analysis using the Monte-Carlo Simulation (MCS) method.

2.3 Risk resolution

Once the risks have been identified and analysed, a decision needs to be taken as to how they are to be controlled taking into account the related benefits and costs.

Several risk resolution strategies can be considered, including risk acceptance, avoidance, reduction, research and transfer [1]. As an example for risk transfer, which is a strategy to shift the risk to another person, group, or organization, construction risks can best be eliminated by a \`fixed timescale turnkey contract\`.

The core of risk management is to be aware of all kinds of risk and to develop a plan to eliminate or minimise them in a cost-effective manner. A fuller understanding of the implications of the investment decision with regards to the implementation of a Continuous Quality Surveillance approach will lead to better decisions for all parties involved (plant owner, contractor, manufacturer, and inspection agency).

The key to risk resolution during manufacturing of hydropower components is the implementation of a quality surveillance system based on the CQSS.

3 Supply Chain Risk Management for Hydropower components

Supply Chain Risk Management is the implementation of strategies to manage both every day and exceptional risks along the supply chain, based on continuous risk assessment with the objective of reducing vulnerability and ensuring continuity. Our analysis is limited to the technical risks during manufacturing of the components for a Hydropower project.
The following usual risks can be identified during manufacturing of hydropower plant components:

- delivery delays.
- manufacturing errors and modifications required on components to allow assembling with defective parts.
- re-engineering and re-design for suppliers and customers, following the detection of non-quality in a late stage of construction.
- risk to safety.

We also notice that manufacturing defects are often due to a supplier's lack of specific experience, to side-effects of the efforts to deliver on time, to misunderstanding of technical requirements, an excessive workload, or general human errors that could be avoided with proper surveillance.
For each of the above risks, a proper Supply Chain Risk Assessment should be carried out and the results should be used to put in place a suitable Quality Surveillance program. This should be done by the Plant owner or by the contractor with the following objectives in mind:

- Identify and manage the risks that are constantly present
- Identify and manage the risks that are related to specific situations
- Inform the parties involved about the level of risk to which they are exposed
- Make sure the knowledge and experiences related to the risk management are shared with all parties involved (by means of training and specific instructions).

3.1 Risks that are constantly present

By identifying the risks that are inherent to the product manufacturing, a systematic action plan should be written for each product purchased to provide instruction for ordinary surveillance activities. The plant owner or the contractor may issue specific guidelines for the preparation of the inspection test plans for each kind of component (valve, shaft, runner, etc.).

3.2 Risks that are related to specific situations

By identifying the risks that may occur within specific projects or unusual situations, it is possible to plan countermeasures, an example could be the use of unusual materials for certain components, that require additional tests. For each identified risk, it is required to evaluate its impact and likelihood. The necessary resources and actions need to be determined and put in place to limit its effects.

3.3 Communication to all parties involved

The success of a project depends on the knowledge and management of potential risks. It has to be stressed, that identifying the risks and determining countermeasures is not sufficient, unless all parties involved (Plant owner, contractor, consultants, manufacturers, inspection agency) have been duly informed about the strategies that have been put in place.
For this purpose the pre-inspection meeting is the key instrument to share the above strategies.

3.4 Sharing risk-related knowledge and experiences

The basis for risk management is the determination of the responsibilities of all parties involved; the actions put in place are successful if all concerned people are allowed to take decisions in a strategic way within the framework of the assigned duties.
The training of the involved persons is critical to the project, as well as having clear instructions to work with.
The key instrument for sharing risk-related information is the Inspection and Test Plan (ITP) that defines the witness points for all testing activities.

Hydroelectric power plants need strict requirements with regards to the safety and productivity of the plant. A Supply Chain Risk Assessment can help to keep the risk for Non-quality under control; if revealed during the construction, commissioning and operation of the plant, Non-quality may lead to huge costs with regards to safety (loss of human life), as well as productivity.

4 Continuous Quality Surveillance Scheme (CQSS)

Further to a Supply Chain Risk Assessment, a surveillance program should be put in place to minimize the impact on quality during the manufacturing of components for Hydropower plants.

In the Continuous Quality Surveillance Scheme (CQSS), the critical processes must be monitored from the beginning and for the whole duration of manufacturing.
Surveillance of conformity of incoming material utilized, through to the final inspection makes possible the detection of defects that otherwise would remain hidden until the operation of the plant [4]

The CQSS relies on the following instruments:

- Continuity of the appointed inspector intervention (through Inspection Agencies)

This means allowing a single person or a few people (the appointed inspectors / inspection agency), with the required skills, abilities and knowledge, to be in charge of the whole project from the inspection's point of view. Training and education of the appointed inspector is critical. He must possess a sufficient technical knowledge and experience to ensure he can understand the risks identified and pass this information on to the manufacturers

- Pre-inspection meeting (PIM) at the preliminary stage of construction.

Experience leads us to consider the PIM as the point of clarification of all the technical and quality aspects for all the subjects involved in the project (client, contractor, supplier and inspection agency), and allows the communication of the level of risk identified to all parties involved.

- Inspection and Test Plan (ITP), detailed with specific witness points for each critical production step.

The Inspection and Test Plan (ITP) is one of the most valuable results of a Supply Chain Risk Assessment. It is a document for quality control defining all the inspections and tests required during the construction process. For each point of inspection, the level of control required for each subject involved must be indicated (client, contractor, supplier and sub-suppliers, inspection agency).
This allows the formalisation of surveillance during the whole manufacturing process, until completion and delivery.

The frequency of the intervention points assisted by the appointed inspector (witness points) is determined by the client depending on the importance of the component as a result of the Supply Chain Risk Assessment.

- Formalisation of interventions by means of Notification of Inspection (NOI).

Referring to the points of inspection reported on the ITP, the vendor is responsible for notifying the scheduled inspection dates to all the subjects involved. The vendor must issue upon notice a Notification of Inspection (NOI) indicating the kind of control, applicable ITP line, date and duration forecasted for the activity and in general all the information required to carry out inspection activities in compliance with the ITP.

- Expediting activities to verify the effective progress of works, detecting and avoiding bottlenecks.

Hydropower components manufacturing is usually characterised by a very tight schedule, where most activities are critical to the timely delivery; for this reason a proper expediting program is recommended to identify and help solve potential problems that could affect construction and cause delivery delays. Problems could include: missing approved documentation, excessive workloads and inefficient technical communication between those involved in the project.

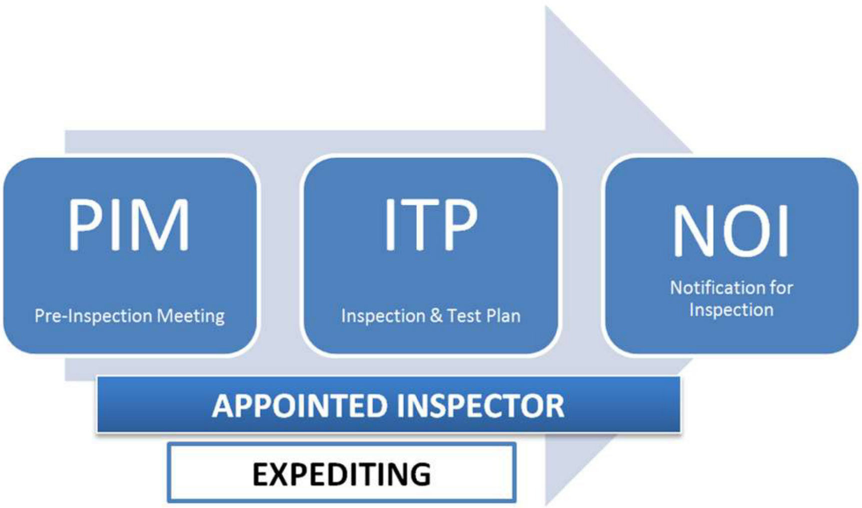

Fig. 2. Logic scheme of a CQSS system

5 Continuous Quality Surveillance Scheme (CQSS) on the field

It is important that a thorough surveillance of the manufacturing process is applied during the whole manufacturing path. An error at an early stage is very hard to fix afterwards and could be potentially disastrous, once the mechanical and electrical equipment are delivered to the powerplant. The key to an effective CQSS system is:

- the inspection agency, that should be selected by the Plant owner or the contractor based on the efficiency of its coordination system, and on its capability of passing the technical requirements from the Client on to its inspectors.
- the inspectors used by the Inspection Agency, that should be selected based on their education, experience and qualifications.

5.1 The Inspection Agency

The Inspection Agency's mission is to organise the inspector's activities with the highest efficiency and efficacy, providing to the client the best way to keep the risks identified by the Client with regards to manufacturing under control.
The back-office personnel (management, job coordinators, technical coordinators and administrative personnel) add a remarkable value to the inspector's work, who can be focused on the mere in-field surveillance activities.
It is a critical duty of the Inspection agency to gather the necessary technical documents (such as ITP, drawings, and testing specifications) and to pass them on to the inspectors.
The Inspection Agency is also in charge to provide the inspectors with a continuous training program both on technical and organisational aspects, and to offer them a global technical support before, during and after the inspection, recording the lessons learnt during the inspection activities for the use of the whole team.

5.2 The inspectors

The Inspectors are the eye of the Client at the manufacturer's premises. They are technical engineers who physically carry out the Quality Surveillance during the manufacturing of the products in the manufacturer's plant.

The inspectors shall possess a remarkable experience in the manufacturing of hydropower components and also in the testing techniques such as Visual, Liquid Penetrant, Magnetic Particle, Ultrasonic and Radiographic examination. In case of non-conformities or critical deviations the inspector in attendance will be able to take immediate action, informing the Client with detailed surveillance reports with pictures or sketches to clarify the situation in detail referring to the applicable technical documentation.

A few examples of quality problems that may be detected during the manufacturing of components for hydropower plants are described in the pictures from Fig. 3 to 7:

Fig. 3. Kaplan turbine blade: Defects on casting detected by means of Liquid Penetrant examination

Fig. 4. Francis wicket blades: Excavation and welding repair of casting defects

Fig. 5. Welding defects

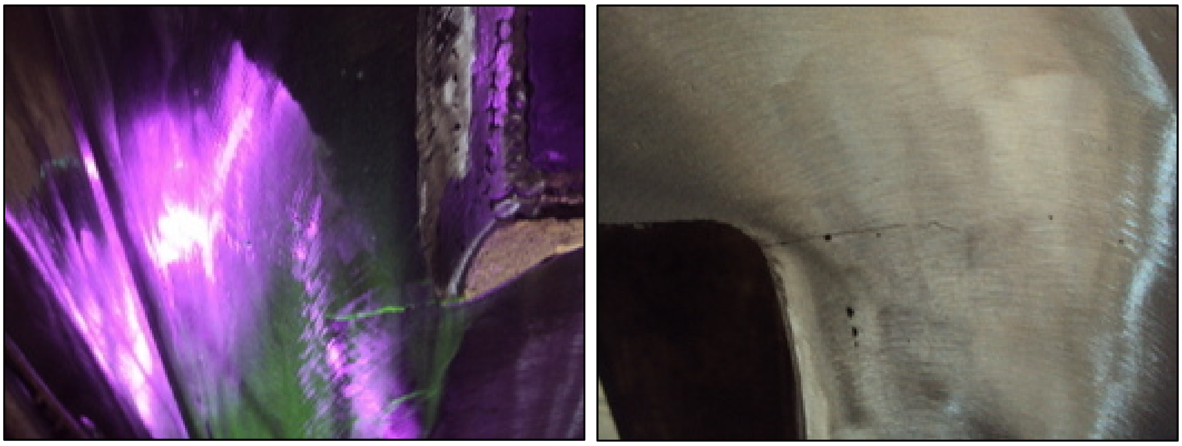

Fig. 6. Francis turbine stay rings: cracks detected in structural welding by means of Magnetic Particle examination

Fig. 7. Spherical Valve Body: porosities detected by means of Liquid Penetrant examination

6 Conclusions

In huge facilities, such as hydroelectric plants, unfortunately it is not always possible to prevent risks that may acquire dramatic implications, even with hazard to human life.
Discovering poor quality at a late stage can add an exponential increase to the costs, with dreadful consequences for the client and the development of the whole plant. On the contrary, by using the proposed methods of work and good quality surveillance, there is a chance to discover poor quality as soon as it appears, thus allowing for immediate solution. Companies using the above methods of work have reported significant improvements in their supply chain efficiencies. They have helped identify inefficiencies and configure the supply chain, working to achieving the industry's best practice standards.

References

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