CONTINUOUS QUALITY SURVEILLANCE SCHEME TO MINIMIZE THE COST OF POOR QUALITY IN THE CONSTRUCTION OF HYDROELECTRIC POWERPLANTS

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1 INTRODUCTION

COST OF POOR QUALITY (COPQ)

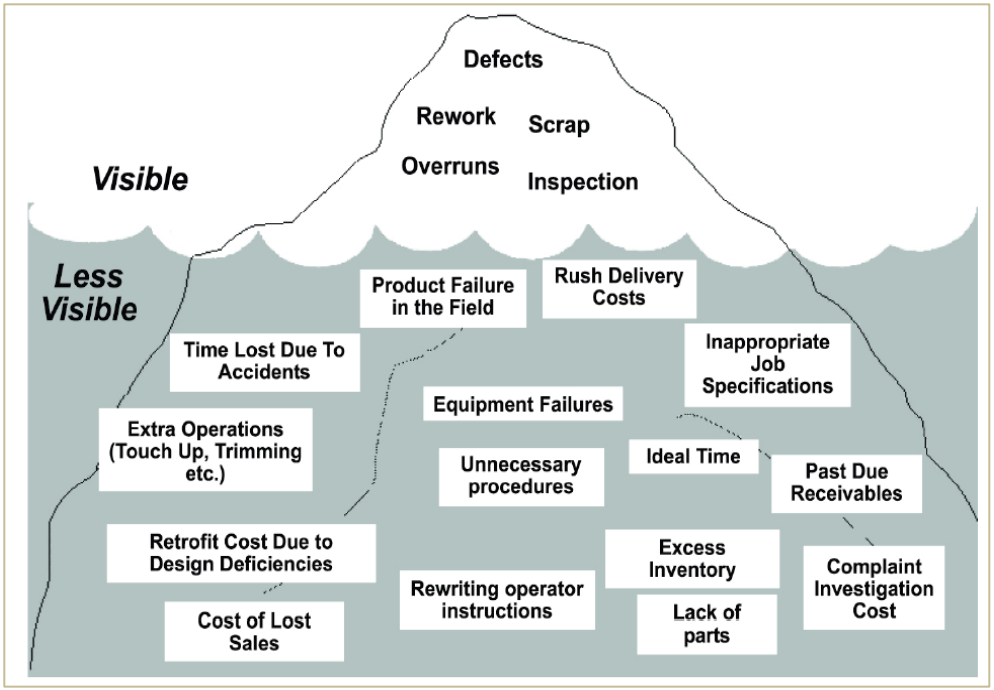
- Turbines
- Generators
- Valves
- Transformers
- Penstocks
- Etc.

SAFETY
Risk for human life

PRODUCIBILITY
Loss of production

We hereby propose a **manufacturing follow-up method** to minimize the Costs of Poor Quality

2 COPQ RELATED TO MANUFACTURING



C Cost
O Of
P Poor
Q Quality

(six sigma model)

COPQ = Internal Failure Costs + External Failure Costs

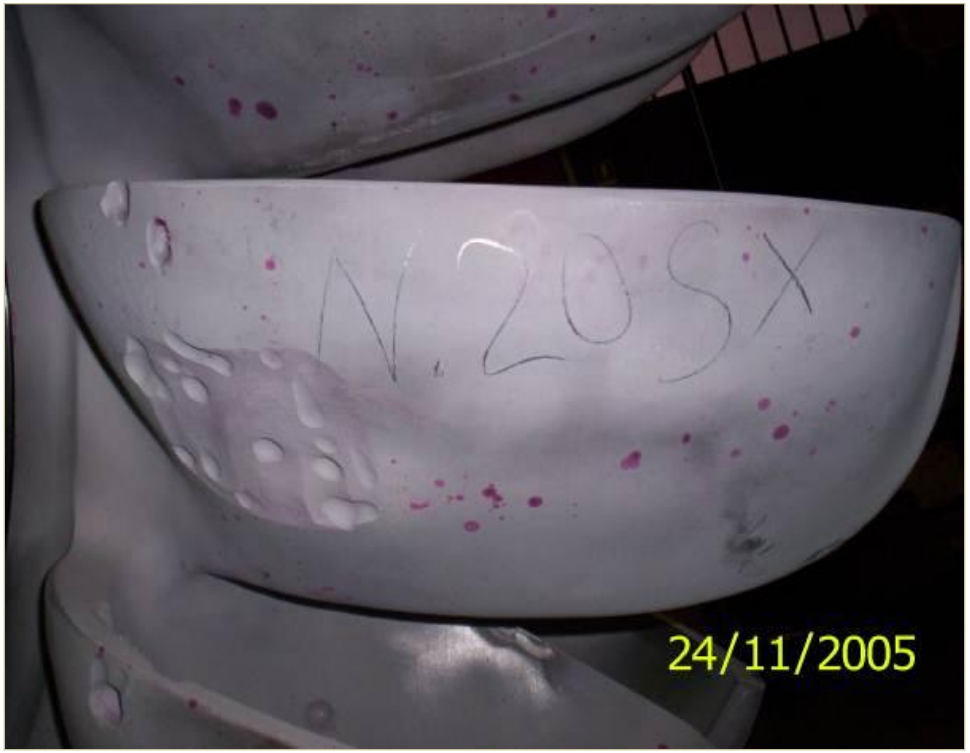
IFC = Scrap Costs + Rework Costs

EFC = Returned Product Costs + Warranty Costs + Product Recall Costs

2 EXAMPLES OF DEFECTS DETECTED DURING MANUFACTURING

Example of POOR WELD PREPARATION AND OF POOR QUALITY WELD ON A ROTARY VALVE

2 EXAMPLES OF DEFECTS DETECTED DURING MANUFACTURING



Example of excavation of DEFECTS ON A CAST PELTON RUNNER

2 QUALITY CONTROL DURING MANUFACTURING

TECHNICAL SPECIFICATION (MATERIAL REQUISITION)

→

CONSTRUCTION DRAWINGS

VENDOR PROCEDURES

QUALITY PLAN

The Quality Control during manufacturing consists of **VERIFYING THE CONFORMITY TO THE CONTRACTUAL TECHNICAL SPECIFICATIONS AND TO APPLICABLE STANDARDS,** and to drawings, Quality Plans and vendor procedures.

2 EXAMPLES OF QUALITY CONTROL DURING MANUFACTURING

Non-destructive examination by LIQUID PENETRANT on a WHITE METAL BEARING

According to applicable international standards, e.g. ASTM E165, ASME V art. 6, ASME VIII app. 8, EN 571, EN 1289, etc.

2 EXAMPLES OF QUALITY CONTROL DURING MANUFACTURING

Dimensional check of BOLTING FOR TURBINE COVERS

2 EXAMPLES OF QUALITY CONTROL DURING MANUFACTURING

Non-destructive examination by LIQUID PENETRANT on a PELTON RUNNER according to CCH70-3

2 EXAMPLES OF QUALITY CONTROL DURING MANUFACTURING

Dimensional check of TURBINE SHAFTS AND COVERS against construction drawings

3 SAYANO-SHUSHENSKAYA POWER PLANT ACCIDENT, RUSSIA

A **catastrophic accident** happened in August 2009 at Sayanogorsk, Russia, affecting the turbines hall and transformers of the **Sayano-Shushenskaya hydroelectric power plant**.

3 SAYANO-SHUSHENSKAYA POWER PLANT ACCIDENT, RUSSIA

The facility had ten Francis turbines of 640 MW each producing 24 TWh/year.

3 SAYANO-SHUSHENSKAYA POWER PLANT ACCIDENT, RUSSIA

A large quantity of water coming from the Yenisei River knocked down the turbines hall, provoking the **explosion of at least one transformer. All the turbines were badly damaged.** **75 people were killed during this accident.**

3 SAYANO-SHUSHENSKAYA POWER PLANT ACCIDENT, RUSSIA

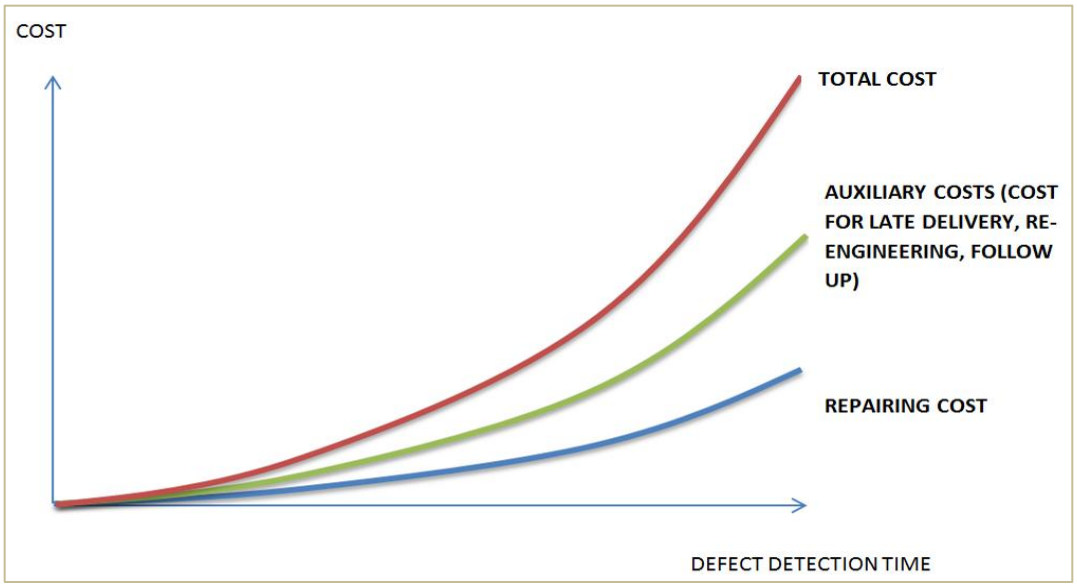
The report identified the cause of the accident to be **a bolt failure in the cover of one turbine**, due to vibrations. **49 bolts retrieved after the accident were tested and fatigue cracks were detected on 41 of them.**

4 CONTINUOUS QUALITY SURVEILLANCE SCHEME (CQSS)

CONTINUOUS QUALITY SURVEILLANCE SCHEME is a philosophy of follow-up of manufacturing oriented to quality

APPLIED TO THE MANUFACTURING OF MECHANICAL AND ELECTRICAL COMPONENTS FOR HYDROELECTRIC POWER PLANTS

4 CONTINUOUS QUALITY SURVEILLANCE SCHEME (CQSS)



In the Continuous Quality Surveillance Scheme (CQSS), the critical processes must be monitored from the beginning and for the whole duration.

THE DEFECTS SHALL BE CORRECTED AS EARLY AS POSSIBLE!

4 CONTINUOUS QUALITY SURVEILLANCE SCHEME (CQSS)

In particular the CQSS relies on the following instruments:

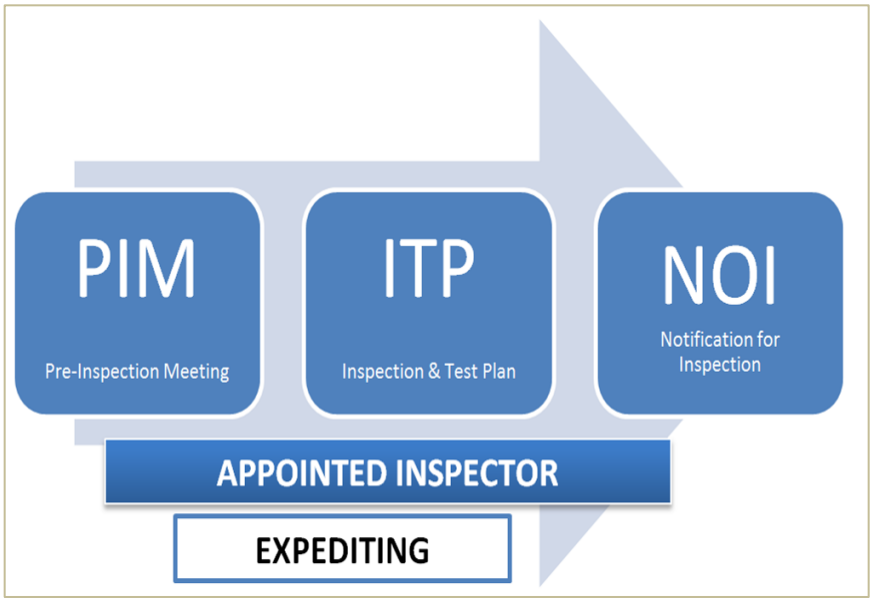
(1) Continuity of the **appointed inspector** intervention (typically leaning on Independent Inspection Agencies).

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

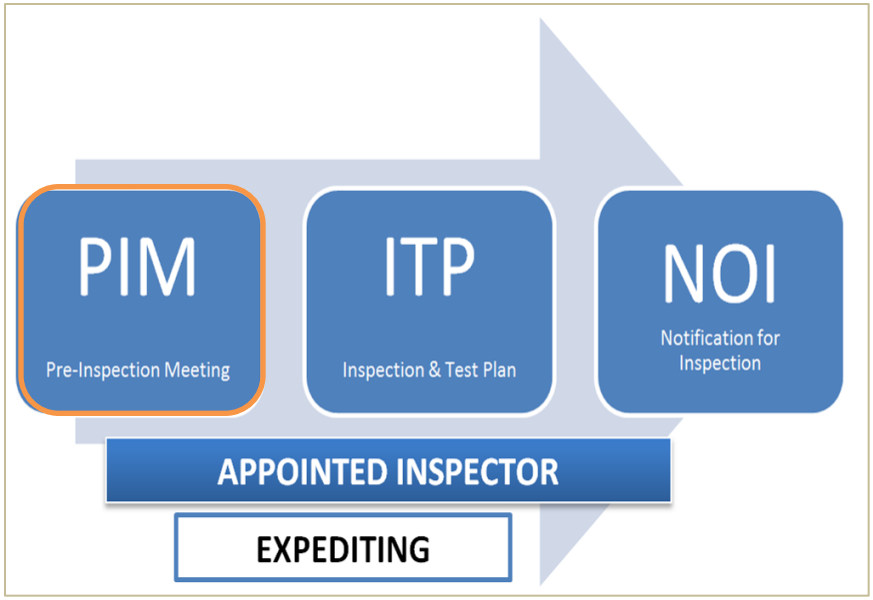
(3) **Inspection and Test Plan** (ITP), detailed with specific witness points for each critical production step.

(4) **Formalization of interventions** by means of Notification of Inspection (NOI).

(5) **Expediting activities** to verify the effective progress of works, detecting and avoiding bottlenecks.

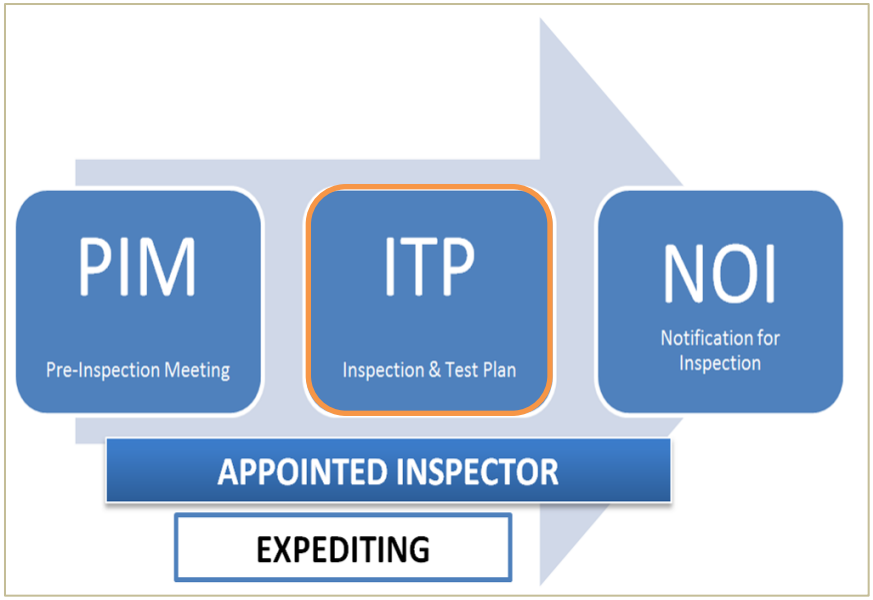


4 CONTINUOUS QUALITY SURVEILLANCE SCHEME (CQSS)



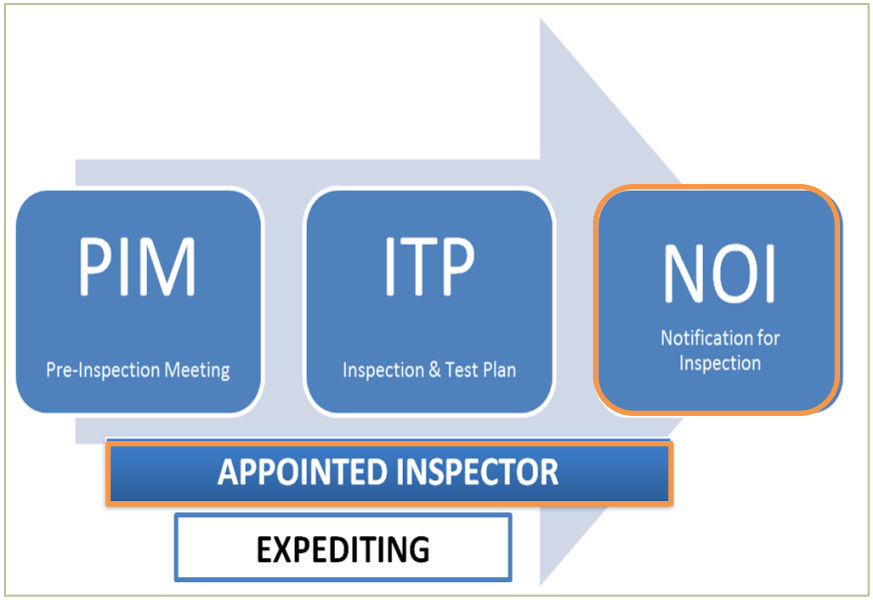
The **Pre-Inspection Meeting** (PIM) is a meeting among vendor, Client and the appointed inspector and should always be carried out at the beginning of the manufacturing, to **clarify all technical and quality issues.**

4 CONTINUOUS QUALITY SURVEILLANCE SCHEME (CQSS)



The **Inspection & Test Plan** (ITP) is a Quality Control document that defines all inspection and test activities required during manufacturing. It allows for formalizing the **surveillance during the whole production process,** until completion and delivery.

4 CONTINUOUS QUALITY SURVEILLANCE SCHEME (CQSS)



Based on the inspection points identified in the ITP, it is the vendor's responsibility to inform all parties involved (Client, End Client if any and Inspection Agency) about the scheduled dates by means of a **NOTIFICATION FOR INSPECTION.**

5 CONCLUSIONS

A CQSS (Continuous Quality Surveillance Scheme) approach makes it possible to reduce Cost of Poor Quality, showing potential problems as soon as they appear and **allowing for immediate solutions**.

Discovering non-quality at a late stage of construction of the single components **may bring an exponential increase in costs**, with delays and dramatic consequences for the customer. It can also increase the cost for the whole hydropower or water resources project. In some cases, it can cause issues of considerable safety risks. In extreme circumstances**, it can lead to the loss of human life!**

THANK YOU FOR YOUR ATTENTION!