CHAPTER 6

IWS AND TPM STANDARDS FOR NEW TECHNOLOGY TRANSFER PROJECTS IN THE COMPANY

So far a general overview of what the organization relies upon has been provided, in terms of people, systems and philosophy. These three factors are needed in a manufacturing company to produce what it will actually sell: products that must meet the highest quality standards and the lowest delivery costs, understanding as such, the sum of all costs needed to put an item on the shelf of the supermarket, everything from raw materials, packaging, transportation, distribution, marketing, etc.

In order for these costs to be at their lowest levels, everything possible must be done to ensure that no losses will exist through the process. One of the main opportunities that a company has to abate losses is precisely the introduction of new equipment and/or processes in its facilities. Better technology allows for better operational costs, by default, however, the way many companies deal with new engineering initiatives leaves way to much to luck. Companies tend to think that buying something new, means that no problems are carried along. Unfortunately, buying a new machine is not like buying a new car. Especially in the process industry, a piece of equipment may not be useful by itself, it will most certainly have to be connected with a series of pumps, pipelines, wiring, etc. This is particularly prone to mistakes; up to the tiniest weld point must be done to perfection to avoid leaks from the very beginning. A series of tests and inspections must be carried on to ensure that the start-up will be successful, that no losses will be generated and most importantly, that no accidents will occur.

Through this chapter a review will be presented on how each of the 8 TPM pillars interact under the IWS concept to develop from scratch a successful engineering project. It is in this chapter precisely where it will be seen what the organization requires from all its employees working around such a project, here is where all the systems and working philosophies are to be proven as effective or not.

6.1 IWS Readiness Criteria

IWS readiness means that a new project is delivered fulfilling a series of very precise specifications. Not one single consideration may be forgotten or underestimated in order to fully comply with the company's expectations which are clearly set clear in several documents that are signed by all those in charge of the different stages of the delivery process. As mentioned previously, the eight pillars of TPM will play a role, more or less important, depending on the nature of the new process itself.

This effort is carried on mainly under the coordination of the Initiatives Management pillar, which as mentioned before, will be developed in further detail along this chapter. It is important to notice that hereafter, the TPM principles and systems will be known as those of IWS instead.

The following paragraphs are an extract of an internal document of the company (IWS Readiness, 2000) which has been modified to comply with the confidentiality agreement signed between both parts.

In general terms, the aim of the IM pillar is to define, design, construct and start-up without losses of any kind, production systems that continuously operate in a loss-free state which is known as the ideal condition. The ideal condition is really achieved when all factors that may contribute to a certain loss (see Table 5.1) are fully identified and a countermeasure is developed according to IWS principles and methodologies.

The IM Pillar's purpose is to deliver IWS ready equipment by first having a solid design base that is built on engineering standards that are developed around loss elimination activities of AM, PM, QA and FI pillars efforts. Lots of documentation will be needed; hence, the role of the A&S pillar is also very important, particularly through the IT department activities.

The following list features a general sketch of the engineering standards required by IWS for new equipment, it is important to note that it may not be fully descriptive and some considerations may not be included here, they are divided in 6 main categories as follows:

1) General design features:
    - all unnecessary parts are eliminated achieving a minimum number of components to achieve optimum equipment functions
    - all components selected for maximum life based on life cycle cost
    - reduced noise equipment operation
    - minimize painted surfaces
    - smoothest, cost justified surface finish
    - control systems not used to minimize inadequate mechanical design
    - equipment components and spare parts are selected from current set of components and spare parts.

2) Safety:
    - all equipment fails safe on loss of utilities

- visible lockouts prevent all possible equipment operation
- minimum operator bending, stretching, reaching for routine operation, adjustment and maintenance.

3) Cleanliness:

- sources of contamination from machine auxiliary systems eliminated (contained or redirected)
- sources of contamination from incoming raw materials eliminated (contained or redirected)
- sources of contamination from equipment contact with raw materials eliminated (contained or redirected).
- sources of contamination from the environment eliminated (contained or redirected)
- minimum number of surfaces
- minimize horizontal surface areas
- all equipment surface crevices filled and flush
- all holes and openings filled and flush
- minimize the number of angles less than or equal to 90 degrees
- radius fill 90 degrees angles
- minimize the total area of equipment contact with floor
- eliminate points of contamination buildup on all equipment-to-floor contact points
- minimize ladders, rails and platforms

- cable, conduit and piping routed to permit easy cleaning
- no open channel for equipment frames
- round tubing preferred over non-round shapes
- CIL standard provided which maintains the ideal condition with minimum time and effort
- equipment subassemblies located to prevent spread of contamination
- eliminate all inaccessible areas created by equipment-to-equipment contact
- provide easy to clean tools when necessary

4) Visual control/inspection:

- easy access to all sections of equipment
- minimum instrumentation necessary to maintain the minimum necessary adjustments
- visual indication of normal operation range on all instrumentation displays
- direction of rotation indicated for rotating elements
- direction of travel of belts/chains indicated
- chain or belt model type indicated at point of service
- belt tension visibly indicated
- all control devices clearly marked for intended function
- positions clearly indicated for devices with multiple operating position
- visible thermal labels on heat sensitive components
- plugged condition of as/air and liquid filters visible
- color-coded change parts

- early visible detection of high wear items
- piping and tubing color-code for content
- flow arrows on all piping and tubing
- equipment internal components can be visually inspected

5) Lubrication:

- lubrication points easily accessible and clearly identified
- lubrication type and quantity marked for lubrication points
- minimum selection of types of lubrication
- properly identify the type of lubricating equipment and/or tools

6) Fastening

- minimum selection of types of fasteners
- critical fastening torque specifications indicated
- fastener anti-loosening measures provided where required
- minimize use of bolt-nut pairs, thread bolts directly into equipment
- visual position indication provided on high vibration service fasteners
- grade of fastener consistent with type of service
- nut located on top for bolt-nut pairs
- extend 3-4 bolt threads past nut

7) Quality:

- unnecessary adjustment points eliminated

- no tools required for adjustment
- consumer benefits related to quantitative product features
- quantitative product features related to quantitative equipment settings
- equipment settings are easily established
- equipment settings do not change/drift
- equipment setting changes are easily recognized
- equipment setting changes are easy to restore
- visible and lockable adjustment points

8) Maintainability:

- no tools required for equipment adjustment
- minimum or no tools required for maintenance
- minimize need for special tools
- alignment marks scribed on all drive train components requiring timing
- equipment components cannot be installed/assembled incorrectly
- easy to handle covers
- control logic limited to essential machine operation
- routine maintenance without equipment disassembly

This turns out to be a rather complicated list, but it has to be followed regardless. What the IM pillar is got to do now is make sure that all these points are covered, in addition to the equipment being in Step 2 of PM and that all the documentation validating that the operators are capable to use, maintain and administrate the equipment is duly filled out and available at any time.

6.1.1 Life Cycle Cost

Back in the first clause of this list "life cycle cost" is mentioned. But what is this? Well, according to the JIMP, the life cycle cost of a product, equipment or system is nothing more than the total cost through its entire lifetime, it is made up of direct and indirect costs, periodical and non-periodical costs, and any other related to a large scale system through its effective life, including but not limited to all those costs existent from design, development, production, operation, maintenance and support (Suzuki, 1995). Now, what is important to mention here is that this cost, if properly calculated, will allow making better decisions during the design and development phases, where it is possible to ensure an economically attractive product or piece of equipment for the user.

This is a very simple example of how the life cycle cost is calculated:

For this example let's assume 2 competing project designs, A and B. For simplicity, assume each one takes 1 year to design and construct, each one is operated and maintained for 2 years, and each one is to be faded after year 4. The life cycle cost for each design, expressed as net present value (NPV), to the sum of the annual cost(s) for each year of the life of the project, discounted for the time value of money, or interest rate:

$$NPV = \sum_{o}^{n} Cn(1-i)^{n} \qquad \text{Eq. 6.1}$$

Let us assume that: the design and construction cost is \$5 million for Project A and \$5.5 million for Project B; annual operating costs are \$5 million for both designs; and fading costs are \$2 million for Project A and \$1 million for the design for Project B. The interest rate is 5%. Then:

$$NPV_A \begin{array}{l} =5+5(1-05)^1+5(1-.05)^2+2(1-.05)^3 \\ =5+5(.95)+5(.90)+2(.86)=\$15.97\,million \end{array} \qquad \text{Eq. 6.2}$$

$$NPV_B \begin{array}{l} =5.5+5(1-.05)^1+5(1-.05)^2+2(1-.05)^3 \\ =5.5+5(.95)+5(.90)+2(.86)=\$15.61\,million \end{array} \qquad \text{Eq. 6.3}$$

In this example, the estimated life cycle cost of the design B is 360 MUSD less than Project A and therefore is, financially speaking, far more attractive (Haka, 2000).

Through IWS principles, a set of 5 basic steps are available that will be helpful in this process:

1) Clarify the mission of the system, product or equipment
2) Formulate several alternate proposals that accomplish the expected mission
3) Identify the criteria to properly evaluate the system, product or equipment and all the techniques required to quantify this evaluation.

4) Evaluate the proposals

5) Document the analyses and processes carried out

In the case of the new technology transfer project that this research project deals with, it is absolutely necessary that the customer and the supplier get together, from the earliest stages of the project, and start off from this 5 steps. One solution is usually what is expected but it might not be the best one, that's why alternatives should always be there to turn to in case something goes wrong.

Also important in the effort to reduce the life cycle cost of a project is to design based upon preventive maintenance guidelines. This is again where the PM pillar gets to work closely with IM, one can see here that PM actually must come first than AM to leave as few design flaws as possible to fix during installation and start-up. Let's talk about it a little bit more in the next section.

6.1.2 Designing with Preventive Maintenance in Mind

Usually, even though the design and construction of a given machine seem to be running smoothly, the operating team may find several difficulties to get it running during the testing and/or start-up stages. Then, after numerous modifications, they somehow manage to get it working, but perhaps not as expected. Through IWS, the organization can do much better.

The design process for a new machine is carried out while keeping in mind the experience that is had with similar equipments one can seek to have the lowest future maintenance costs and the least wear rate because many problems will be solved before they actually show up. One can get high safety, reliability, maintainability and operability without really sacrificing features or functions. Modern technology allows having hi-tech and low cost solutions to any problem may be found at the workplace. Of course, the benefit of experience may not always be there for the company if it is acquiring something totally new for it.

Ideally speaking, if the machine was designed according to the mentioned approach, it must not break down or produce out of specifications items. This is where the design team will require all the possible feedback from the operating team, who can know better a machine than those that work with and around it everyday? (Suzuki, 1995).

What must be avoided at any cost is the following scenario:

"A new machine was just started up but it is very difficult to inspect, lubricate and clean. It is necessary to avoid failures or defects but it is amazingly difficult; preparing for a repair or adjustment is awfully delaying, the simplest fix requires a huge amount of downtime." These are common thoughts in the shop floor, and why does this happen? Because the designer, presumably a mechanical engineer, never thought about developing an easy-to-use, easy-to-clean and easy-to-adjust machine. He or she just squarely focused in the machine doing what it is supposed to, no questions asked. Maybe that was the way it was done a couple decades ago, but not any more, yet, amazingly, one can still find this everywhere. Sadly enough the concept of concurrent engineering is not sufficiently underlined in the classroom. Colleges all around the globe keep sending out engineers that do not want to realize that the machines they design will eventually have to be used, cleaned, maintained or adjusted somewhere by somebody. Unless this way of "doing" engineering is changed, designing will remain totally out of the context of modern times.

6.1.3 Quality Assurance

When a several thousands of dollars investment is made in a new machine it is expected to yield profits from the very first moments it is put to work, and it really shouldn't be otherwise, as difficult or absurd as this may sound. This ideal state would not really require the QA department to be concerned more than usual, yet, many things can go wrong, especially if all the processes mentioned earlier are not duly followed, therefore, whenever a start-up is scheduled, the QA Pillar is an excellent resource to make sure that no out-of-specifications products are sent to the next process stage, which would constitute a quality incident by definition.

Once QA validates that the production is quality-compliant the organization can start to focus in some other just as important things.

6.1.4 Education and Training

The examining process that students are subjected to at school may be underestimated. One can study one day before a test and have the knowledge "fresh" in one's minds the next morning. Well, modern industry cannot depend on last-minute study. The education and training process (E&T) that is required in the shop floor is much more than that. There is a need to certify that an operator is skilled enough to perform a given task completely error-free. Obviously this cannot be accomplished with simple written exams; there is a need to go deeper into the process, or rather to the process itself.

Independently of the certification method chosen, the improvements need to be documented in an IWS approved database. Such a document is known as a skill matrix, in addition with a step-up card. While the first one contains the skills and knowledge that an operator for a certain area must possess, the latter indicates how proficient he or she is in each one of them.

A very important point here is that the role of the E&T Pillar is only to coordinate and enable the production department in this effort. Generally, these tasks are carried on by the area leaders or the most skilled operators, in this way, the technical expertise of the production line is recognized and nurtured. Everyone has heard that the best way to learn is to teach, and this is rather true in this case.

Particularly when it comes to new machinery, the training process is first carried on with those who will provide it to the rest of the area's staff. The supplier of the equipment trains, for example, the process engineer in the operation, inspection, cleaning, maintenance and start-up. Then, in conjunction with the E&T pillar, a skill matrix and step-up cards are developed and finally, training sessions are scheduled. During or after start-up, the operators are to be certified and their improvements documented. All new employees that incorporate to the area must follow the same procedure.

This chapter has introduced the standards and expectations that the company has around the project being studied. It sets the rules under which the project team should behave, clearly stating what and how to do it through IWS methodology and support from each pillar. This is ultimately the reason why these pillars exist, to aid the organization to do business exactly as the corporation requires it. Through the interaction of the 8 pillars with each area of the plant, the results that are achieved are effective and long lasting, allowing the organization to stay on track, along the "zero loss journey" that the globalization is demanding in order to remain competitive.

Now, through the remaining of this research project an analysis will be conducted on how all these expectations have been directly applied in the project, what was easy to do, what wasn't and what was the outcome of the IWS implementation effort in this technology transfer project.