OPERATION AND MAINTENANCE MANUAL AS A PART OF QUALITY CONTROL TOOLBOX

1 General

Maintenance manual can be determined as a file of detailed documents and information that are needed in maintaining a building or a real estate during its lifetime. There are several advantages that can be reached by creating good quality maintenance manual and using it regularly. It helps for instance in:

- Managing facilities and buildings
- Optimizing the service lives of the building elements and HVAC-systems
- Verifying their performance and usability during the service lives
- Optimizing the maintenance and life cycle costs
- Keeping up good indoor climate
- Monitoring energy use
- Reaching the energy consumption targets
- Ensuring security
- Identifying risks
- Taken into account the environmental values

There are many ways to create a successful maintenance manual. These solutions vary from paper versions to modern sophisticated information technology solutions. Modern software solutions can be divided roughly into three categories: stand-alone versions, versions used via intranet and versions used via internet. Well organized modern maintenance database can be utilized in real time by building owners, maintenance or service companies and even the end-users. Data available for different interest groups can be determined and restricted (figure 1).

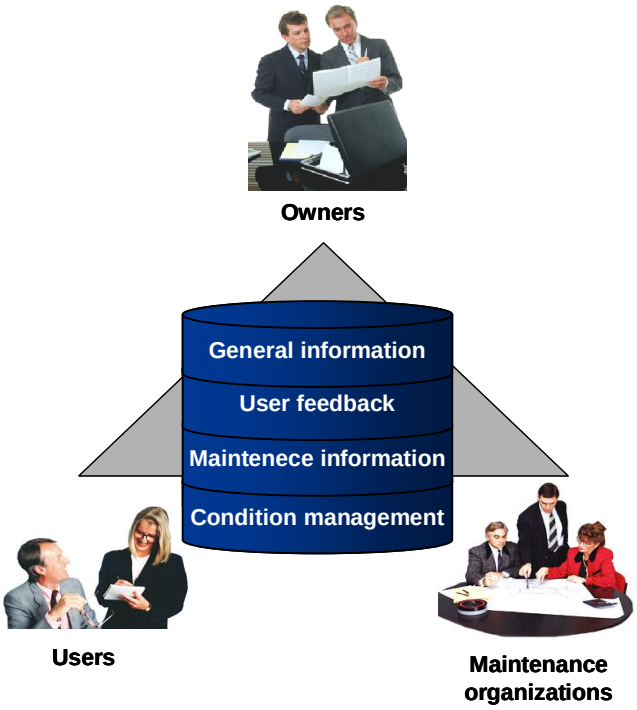

Figure 1. Modern facility maintenance databank can be utilized in real time by different facility interest groups. Data available for different interest groups can be determined and restricted.

2 Contents of the operation and maintenance manual

The execution of the maintenance and operation manual for new or retrofitted buildings should be started in the early designing phase of the building project. Several decisions have to be made in the early stages of the project, for instance:

- What kind of maintenance manual software or system should be chosen?
- What data should be collected and from where?
- Who is in charge of the data collection and coordinating?
- In what kind of format should the collected data be converted?
- Who is paying the costs caused by the maintenance manual execution and its upkeeping?
- How and when to organize the maintenance personnel training?
- How to organize the administration and upkeeping of the manual?

Today there are dozens of different maintenance manual software trademarks available. Selection should be done in line with required functional targets. It is desirable to test and compare between different software systems before the final decision.

It can be put a huge amount of data into the latest maintenance software systems. That is why it is very important to determine exactly what data is important and useful for the maintenance. It is good to bear in mind that the basic function of the maintenance manual is simple. A good quality manual gives the answers to the following questions:

1. What to maintain and where?
2. How to maintain?
3. When to maintain?
4. Who is in charge of the maintenance?
5. What kind of information should be recorded in the manual from each maintenance action?

One example of maintenance and operation manual data is shown in table 1.

It is useful to include some general data of the real estate of building to be maintained into the manual. This general information should cover at least the following:

- Identification data of the real estate or building (codes, locations, addresses etc.)
- General information of the scale of building (volumes, areas, number of storeys etc)
- General information of land use and its rights, site
- Essential documents of the building or retrofitting project (planning material like drawings, layouts etc.)
- Reports and surveys (condition surveys, energy audits, etc.)
- List and contact information about architects an designers, contractors and entrepreneurs, manufactures and suppliers and maintenance & FM-organizations
- Maintenance and FM-contracts
- Information about tenants and occupiers and their contact persons
- List of apartments and rooms including the data of areas and the occupiers
- Main maintenance and indoor air quality targets (room temperatures, maintenance and cleaning cycles etc.)
- Maintenance cost and energy use targets and guidelines for their monitoring.

Table 1. An example of useful data in a public building operation and maintenance manual, providing an existing building automation system (BAS) and building energy management system (BEMS).

Building condition data	Room/Space condition data	Maintenance object data	Maintenance task data	Maintenance calendar	Economical data	Other useful data
General building condition data	General room/space condition data	Maintenance object classifying system	Maintenance task classifying system	Maintenance task scheduling	Energy and water consumption targets	Regulations, recommendations, instructions, best practices
Fault- and repair history	Room/space condition targets	Maintenance object identifying data	Preventive maintenance task instructions	Daily and weekly maintenance tasks	Actual energy and water consumption measurement data	Security, guidelines for state of emergency
Condition survey data	**BAS/BEMS System information and user interface**	Maintenance object basic data (equipment certificates)	Preventive maintenance task cycles	Monthly and yearly maintenance tasks	Maintenance cost targets	Contact information (designers, builders, FM-services etc.)
Energy audit data	Instrumentation and sensors information	Operational principle of maintenance objects	Instructions for unexpected maintenance	Long period maintenance task data	Actual maintenance cost data	Service contract data
Service life data	Indoor air quality measurement data	Operation and use history data	Task history data	Maintenance diary or notebook	LCC- and LCA- data	Building user/tenant data
Replacement and repair cycle data	Indoor air quality data analysis	Device-specific data	Help desk data	Maintenance feedback data	Economical data analysis	Training procedure

One of the most important tasks in creating the effective maintenance manual tool is to systematize and classify the actual maintenance targets (building elements and HVAC-systems that need maintenance) and then gather and store the basic information of these targets. Each maintenance object should be easy to identify easy to be found. Furthermore plenty of data about these objects is often needed during the maintenance task. Identification systems vary from case to case. One useful way is to give identification code to each separate maintenance object. These kinds of numbering can be done by dividing the objects into main- and subcategories. Clear information about the location of the object and the access to the object is essential to carry on the tasks efficiently. Basic data of the maintenance targets should include at least the information about manufacturer/supplier, installation year and targeted service life.

Maintenance instructions constitute a know-how databank about how to maintain the building and its elements. Usually this information is based on the manufacturer's or supplier's instructions and the practical experience of the maintenance organization. Manufacturer's or supplier's instructions should be stored already in the early phases of the building or retrofitting projects.

Generally maintenance tasks are often classified into two categories: planned maintenance tasks and unexpected maintenance tasks. Concerning planned maintenance it is often appropriate to classify the tasks into different categories by the cycle of the task. Terms like daily tasks, weekly tasks and monthly tasks are often used. Task scheduling should be done in a line with the condition targets and resources. The answer to the question "when to maintain" can be reached simply by creating a service calendar where each maintenance task is determined and scheduled. This requires careful

maintenance planning. In the calendar view the maintenance tasks to be executed are listed. Sophisticated maintenance tools of today enable the access to the maintenance instructions via calendar view. Calendar view should clearly show which tasks are completed and which are unfinished or delayed.

Modern maintenance software systems can be linked with the building automation systems. The cooperation of these two systems is essential in order to manage unexpected maintenance successfully. There are also the help desk systems available for the occupier feedback in modern high level maintenance tools.

Operation and maintenance manual/record book should be connected into BAS, which generates information for OMM and which can be utilized. On the other hand, building automation system should produce information and report in such a form that could be used easily in OMM. Unfortunately, all the useful features of existing BAS are not fully utilized. In practice at the moment. The integration of BAS/BEMS and operation and maintenance manual is the essential task in planning facility management and maintenance. For instance, most of the systems do not provide useful reports on operation, from which one could see the most important factors and key figures. Generally, there are facility management tools available, by means of which one can customize such reports, but the problem is to create proper and targeted information for the end user, building owner or manager.

When the maintenance task is done the task should be noticed by the workers and the vital information about the duty should be stored into files as the maintenance service history (maintenance diary). This information may be utilized later in maintenance planning or in practical future maintenance work.

3 The importance of energy and cost analysis

By means of Operation and Maintenance manual it should be possible to produce at least the following energy and cost analysis data:

1. Monthly target consumptions of heating energy, electricity and water (kWh, kWh/m2 or kWh/m3, water-m3/m2 etc)
    a. In energy units per floor area, volume, users or other factor (e.g. production, worker etc). and
    b. costs per the same factors, detailed key figures selected by the customer
2. Actual measured monthly consumptions (kWh, kWh/m2 or kWh/m3)
    a. the key figures selected by costumer
3. Weather corrected consumptions (heating)
4. Difference analysis (actual compared with targeted, quantities and costs)
5. Difference and trend analysis (actual compared with the previous years, quantities and costs)
6. Comparison with the similar buildings or same type of buildings (if data available)
7. Trends (the changes in the use and cost changes during the time of operation, 5 -10 years period if possible, quantities and costs)

    This provides that BAS can give proper information in a suitable form. The values can be entered also manually, but it is recommended that BAS is linked to OMM in such a way that data required updates automatically. In OMM there should be a report model, or report models which could be customized according to the needs of building owner, user or service personnel.

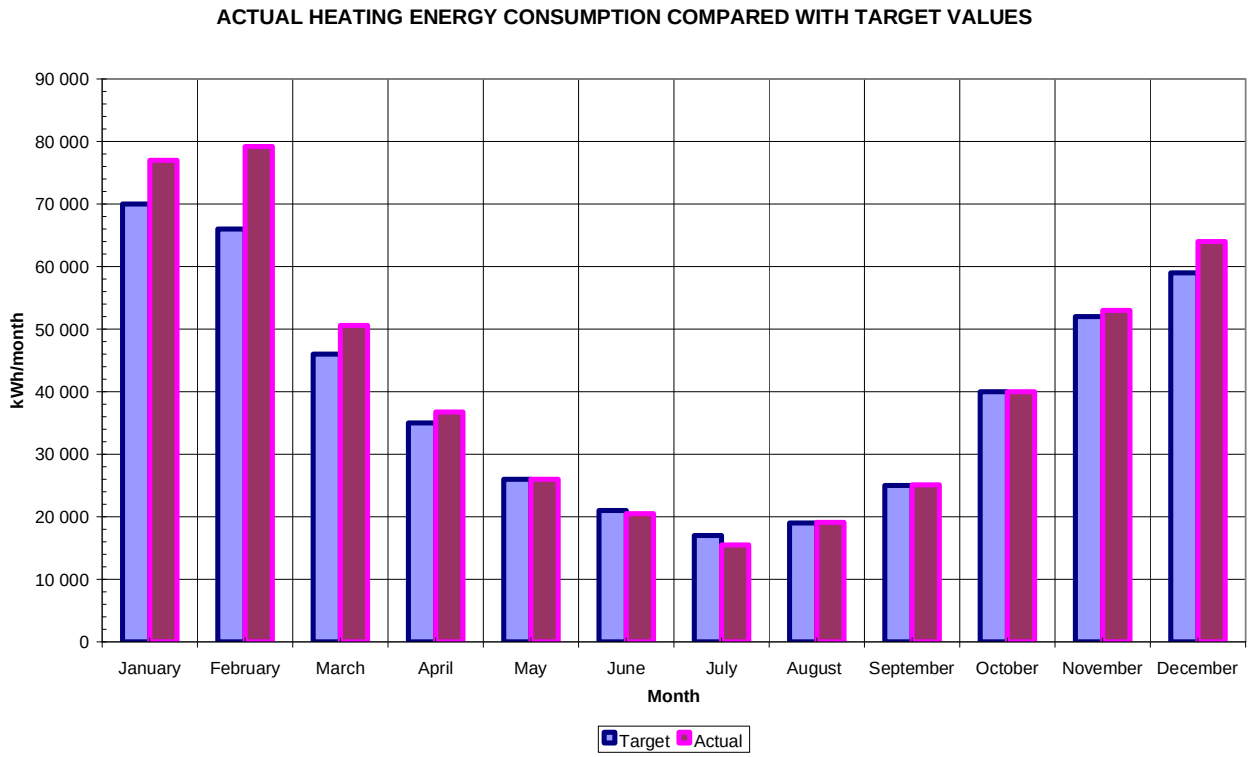

Figure 2. A Schematic diagram of monthly energy consumption targets and actual consumptions.ure

Figure 2 shows a schematic diagram of monthly energy consumption in a public building. In figures 3, nn, mmm there are examples of facility and energy cost management reports (Promain). The monitored topics could be extended dealing with the other facility maintenance items and costs, e.g. cleaning, wastes, disposal, insurances, taxes etc. If the instrumentation level is high enough, the indoor air quality key figures could be added and analyzed by the same way.

Figure xxx shows a costs distribution of wellness centers and spas (based nn facilities). Energy related costs consist about 15-20 % of total facility maintenance costs in this particular branch.

List of actions by which one can ensure that the consumptions are within targeted values

4 The significance of instrumentation

The performance evaluation and determine of possible savings potential is based on measured and calculated values, or partially on some other factors, like plate records, equipment certificates etc. If the instrumentation level in the building is extensive (in any case it must be reasonable, no inappropriate measurements), it is possible to customize various reports, graphs and tables according to the customer's needs based on actual on-line measurements. The level of instrumentation can be compared with the instrumentation in the industry: What kinds of measurements are needed to control the production process and the product quality? If the building and indoor air conditions will be considered as a process where thermal comfort and indoor air conditions are the products, the analogy for industrial processes and instrumentations is relevant. The right magnitudes must be monitored and reported by proper way.