# Condition Assessment Manual

## *Appendix 1.12– Guide for Instruments & Controls System Condition Assessment*




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# Contents

## 1.0 General

The instruments and controls (I&C) system for automation is a critical component in a hydropower plant. Unlike the generators or transformers, catastrophic failure is rare to happen due to automation systems. The fail safe design to protect turbines and generators prevents serious physical damage to a facility. The most common failures in an automation system are failed power supplies, failed I/O, failed processors and lack of information wired to the system. Less common are programming errors that may create issues. Rehabilitation and replacement of an aging automation system may become more economical and less risky than maintaining an outdated system considering the potential efficiency improvement from the state-of-the-art automation design. The condition assessment for I&C system is essential to evaluate the benefits and cost of upgrading.

The plant PLC, SCADA or RTU based automation control system can vary widely from facility to facility. Control architectures have evolved into various types of systems. All these types of systems can perform their intended control functions and effectively control a hydro-electric facility. It is often a personal preference, based on the plant culture, as to what type of automation system is selected. There is some difficulty in writing up a checklist that fits all systems, especially in hardware. The currentchecklist makes basic assumptions and attempts to keep the evaluation as simple as possible. Local plant personnel, plant engineering or central engineering will likely be interviewedin evaluating the automation system. These interviewees are those individuals who are mostly familiar with the automation software and its unique attributes and understand its capabilities in a plant. The ease of implementing improvements in a control system is as much the combination of the skill and training of the plant's engineers and technicians as the automation hardware/software capabilities. Generally, engineering and plant support personnel would like the most current technology and plant efficiencies and thus will be willing to help in the assessment as it will improve their lives at work.

For assessing any type of an I&C system, the following three step analyses are necessary:

1) Whatis the highest level of automation desired at the facility?

* Local manual control only

* Local automatic control with no remote access nor remote control

* Local manual with remote manual control

* Local automatic control with some efficiency and remote access and remote control

* Supervisory control – controlled remotely with efficiency controls (highest level of automation)

2) What is the level of obsolescence?

Obsolescence is a significant factor in an automation system. Turbines and other devices can last 50 years or more. Portions of a control system may become obsolete in as little as 5 years depending on the vendor and the date a particular version was installed. The installed system may be incapable of advanced control, which raises question: Is the system obsolete or undersized and what is required to update or upgrade it?

3) How to assign numerical scores to the system components (rating criteria)?

This Appendix provides guides to answer the above questions, which can be applied to automation control and instrumentation systems regardless of type.The condition assessment is performed using generalized system component names, e.g., using 'controller' to represent any of PLC, RTU or controller. Similar generalization will also be used for SCADA or Data Server. The item of "condition monitoring" combines vibration, proximity (air gap), speed, temperature and partial discharge analysis as a whole (reference to HAP Taxonomy).

## 2.0 I&C System Analysis

There are two workbooks for I&C system due to the different rating metrics and criteria. One workbook is for Automation components (less meters), including condition monitoring (reference to HAP Taxonomy). The other workbook is for Instruments of Unit Performance Measurement (meters).The term 'meters' will be used interchangeably in this document with 'instruments for unit performance measurement'.

The automation system and its components (less meters) are analyzed and listed in Table 1. These are components normally installed in a control room. Automation is the control system that interfaces with all the devices (such asgovernor, breakers, relays) and instruments (for monitoring or metering of power, flow rates, vibrations, turbine speed, headwater level, tailwater level and etc.) via their essential components. An example is the governor, which requires the MW meter to operate. The automation system sends commands to the governor to raise or lower MWs, but does not directly control MW. Automation assessment scoring is different from the mechanical or civil assessments, due to many possible configurations of the automation system.

The Instruments for Unit Performance Measurement used in automation are listed in Table 2. These components have transducers in the field and digital or analog displays on the meters installed in the control room. These meters normally have analog or digital outputs to control systems. Please note the rating criteria for metering assessment are different from the rating scales for the automation. The metering scoring system is similar to mechanical or civil component assessments, such as a turbine assessment.

It is rare for ammeters and voltmeters to fail as there are no moving parts, little chance of contamination, generally very minimal drift over time and they just work for years and years. The plant would not function without them. The wicket gate feedback and Kaplan blade angle readings are required to be accurate for the governors to function properly. In mechanical governors there is little to evaluate as all they have is restoring cables. Synchro transmitters are some of the most accurate measurements in the field and are commonly used for feedback on digital units. Once properly set up, they work well for years. Turbine flow is a relative measurement in most cases. It is physically impossible to have an extremely accurate measurement; even with the Winter-Kennedy taps the measurements are still at +/- 2%. Metering has to work for the plant to operate even in manual, but there is little performance improvement through just better metering. Automation is what brings more value and improved performance.

## 3.0 Metrics for Condition Assessment

As listed in Table1, the following three condition parameters are considered for condition assessment of the Automation System (less meters):

- Hardware Technology
- Software Implementation
- Security Level

These three parameters are regarded as providing the basis for assessing the condition of the Automation System.There is no “Installed Technology” or "Maintenance" category, as they are covered in Hardware Technology and/or Software Implementation, as well as the hardware and software upgrades. Each cell in the worksheet is quite specific and not as generalized as in other assessment manuals. Be sure to read the cell for the weight selected and the footnotes.

As listed in Table 2, the following five condition parameters are considered for condition assessment of the Instruments for Unit Performance  Measurement (metering):

- Physical Condition
- Age
- Installed Technology
- Operating Restrictions
- Maintenance Requirements

Off-site evaluation, after a site visit, will be required to evaluate the vendor current offerings and capabilities versus the installed versions, so the Hardware Technology, Software Implementation, or Installed Technology can be properly scored.

The scores of data quality are determined by the on-site evaluators for each assessed part/item to indicate the data availability, integrity and accuracy and the confidence on the given condition ratings.  In some cases, data may be missing or there may be uncertainty of the component's capability.

## 4.0 Weighting Factors

There are two categories of weighting factors in Table 1 and Table 2.Some condition parameters affect the system condition to a greater or lesser degree than other others; also some components are more or less important than others to an entire control system.  These weighting factors should be pre-determined by consensus among experienced hydropower controls and operations engineers. Once determined, the weighting factors should be largely fixed from plant to plant. The range of absolute values of weighting factors won't affect the Condition Indicator of an automation system, which is the weighted summation of all scores that assigned to a system and its condition parameters.  Facilities that fall under NERC regulations will find that Security will be serious as fines could hit $1 million per day.  Security may have a lower status in the weighting, but it is absolutely essential for any facility.

**Table 1: Condition AssessmentofI&C Automation**

| Automation System Unit ___ | Taxonomy ID | Hardware Technology | Software Implementation[5] | Security | Data Quality Score | Weighting Factors for Components |
|---|---|---|---|---|---|---|
| (A) PLC or RTU or Controller[1] | 4.3.3.1 | | | | | 5.0 |
| (B) HMI (Human Machine Interface)[2] | 4.3.3.2 | | | | | 2.0 |
| (C) Data Server or SCADA[3] | 4.3.3.3 | | | | | 5.0 |
| (D) LAN - Process Control Network[4] | 4.3.3.4 | | | | | 2.0 |
| (E) Historical Archiving & Reporting | 4.3.3.5 | | | | | 1.5 |
| (F) Condition Monitoring[6] | 4.3.1 | | | | | 4.0 |
| Weighting Factors for Condition Parameters | | 3.0 | 4.0 | 1.0 | Data Quality --> | *0.00* |
| Automation Condition Indicator --> | | | | | | *0.00* |

*1 - Due to differences in vendor terminology these are viewed as equivalent

*2 - [HMI and SCADA] or [HMI and Data Server] may be the same device in some systems.
Rate the HMI as a standalone device even though it may be the same physical hardware as the SCADA or Data Server
HMI includes alarming

*3 - Even though these are slightly different in function, there is only one or the other at a plant.

*4 - Includes security evaluations such as firewalls, IDS and Syslogs

*5 - Includes local, automatic and off-site control evaluations and efficiency optimization

*6 - Machine Condition Monitoring for vibration, proximity, keyphasor®, temperature, and partial discharge analysis

**Table 2 Condition Assessment for I&C Instruments for Unit Performance Measurement (Meters)**

| Instruments for Unit Performance Measurement Unit __ | Taxonomy ID | Physical Condition | Age Score | Installed Technology | Operating Restrictions | Maintenance Requirement | Data Quality Score | Weighting Factors for Components |
|---|---|---|---|---|---|---|---|---|
| Generator Voltmeters[1] | 4.3.2.1 | | | | | | | 3.0 |
| Generator Ammeters[1] | 4.3.2.2 | | | | | | | 1.5 |
| Generator MW Meter[1] | 4.3.2.3 | | | | | | | 3.0 |
| Generator MVAR Meter[1] | 4.3.2.4 | | | | | | | 3.0 |
| Generator Field Voltage[1] | 4.3.2.5 | | | | | | | 2.0 |
| Generator Field Ammeter[1] | 4.3.2.6 | | | | | | | 1.0 |
| Wicket Gate Position Indicator[2] | 4.3.2.7 | | | | | | | 1.5 |
| Blade Tilt Indicator (Kaplan)[3] | 4.3.2.8 | | | | | | | 1.0 |
| Head Water Elevation[4] | 4.3.2.9 | | | | | | | 4.0 |
| Tail Water Elevation[4] | 4.3.2.10 | | | | | | | 4.0 |
| Turbine Flow[5] | 4.3.2.11 | | | | | | | 1.0 |
| Weighting Factors for Condition Parameters | | 2.0 | 1.0 | 3.0 | 1.0 | 1.5 | Data Quality --> | *0.00* |
| Metering Condition Indicator --> | | | | | | | | *0.00* |

*1 - Treat each input as an individual meter if multi-function meters are used.

*2 - Wicket gate measurements are commonly made by a LVDT (Linear Variable Differential Transformer) or a slide wire precision potentiometer attached to the gate servomotor linkage at the unit governor or to a synchro position transmitter. The synchro transmitter is likely to yield the most accurate measurement. On units with older mechanical governors, the feedback is a "restoring cable". In this case, the only method of evaluation may be the maintenance records.

*3 - The blade tilt indicator for a Kaplan turbine may be difficult to evaluate outside of any maintenance records. There are two common types of feedback to the governor. The MLDT (Magnetostrictive Linear Displacement Transducer) is used on units with digital governors. On units with older mechanical governors, the feedback is a "restoring cable".

*4 - Frequently in head water elevation and/or tail water elevation, there may be redundancy. Two level transmitters may be used that are of different types tied to two separate meters. As an example for head water elevation, one may be a float type level transmitter and the other a submerged pressure transmitter. One meter may be an analog meter tied to the submerged pressure transmitter and the other meter a digital meter tied to the synchro (float type) transmitter. Both head water measurements may tie back to the control system. If there is this type of redundancy, give a higher score. Rank the higher quality of the two measurement types. A staff gage does not qualify as a meter in this assessment.

*5 - Absolute turbine flow measurement is difficult. Generally pressure taps are used as sources to measure relative flow only. Winter-Kennedy piezometer taps installed in the scroll case with modeling software, is the established way to accurately measure turbine flow. Often, those are only used for "index testing" every couple of years. If Winter-Kennedy type taps are permanently installed and in use, give a higher score.

## 5.0 Rating Criteria

For HAP site assessment, it is important to interview and discuss with plant personnel to score the condition of I&C components. All related information are collected, analyzed and applied to:

- Charts 1-5 Automation Hardware Rating Criteria
- Charts 6-10 Automation Software Implementation Rating Criteria
- Charts 11-15 Automation Security Rating Criteria
- Charts 16-18 Machine Condition Monitoring Rating Criteria
- Chart 19 Automation Data Quality Rating Criteria
- Charts 20-24 Instruments for Unit Performance Measurement(metering) Rating Criteria
- Chart 25 Instruments for Unit Performance Measurement (metering) Data Quality Rating Criteria

The charts listed above will guide the assessors to assign component condition scores. The gathering of data in the checklists will provide detailed information that will likely exceed the requirements for an assessment.

| Chart 1 Hardware Assessment: PLC or RTU or Controller | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Capable of all required and future controls expansion for its area w/o an extensive CPU upgrade. At current revision level and vendor support level. | **9 - 10** |
| **Good** | Not at latest release version, but has vendor support. Not obsolete. Capable of all required and future controls expansion for its area w/o a CPU upgrade. | **7- 8** |
| **Fair** | Considered obsolete by vendor and not configurable by current release software. Capable of all required and future controls expansion for its area w/o a CPU upgrade. | **5 - 6** |
| **Poor** | Considered obsolete by vendor and/or capable of all currently required controls for its area, but not able to handle future controls for its area. | **2 - 4** |
| **Unacceptable** | Obsolete and/or minimal control capability. For example, it can only monitor devices and has limited control. | **0 - 1** |

| Chart 2 Hardware Assessment: HMI (Human Machine Interface) | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Computer (or thin client) has currently supported operating system and currently supported vendor HMI software and is capable of controls system expansion without a significant upgrade. | **9 - 10** |
| **Good** | Computer (or thin client) may have an older operating system and/or older (though supported) vendor HMI software. Capable of controls systemexpansion without an upgrade. | **7- 8** |
| **Fair** | Computer (or thin client) may have an older though supported operating system. The HMI software is considered obsolete. Capable of controls system expansion without an upgrade. | **5 - 6** |
| **Poor** | Obsolete operating system and obsolete HMI software. | **2 - 4** |
| **Unacceptable** | No HMI or simple local digital panels with minimal information. | **0 - 1** |

| Chart 3 Hardware Assessment: Data Server or SCADA | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Computer has currently supported operating system and currently supported vendor software. It is capable of controls system[1] expansion without a significant upgrade. | **9 - 10** |
| **Good** | Computer may have an older operating system and/or older (though supported) vendor SCADA or Server software. Capable of controls system[1] expansion without an upgrade. | **7- 8** |
| **Fair** | Computer may have an older though supported operating system. The SCADA or Server software is considered obsolete. Capable of controls system expansion without an upgrade. | **5 - 6** |
| **Poor** | Obsolete operating system and obsolete SCADA or Server software. | **2 - 4** |
| **Unacceptable** | No SCADA or Server system. | **0 - 1** |

| Chart 4 Hardware Assessment: LAN – Process Control Network | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Redundant LAN or ring which minimizes a single point of failure. Current technology supported by vendor(s). If there is a connection to the Internet or business network, a firewall is installed. All wireless communications are secure. | **9 - 10** |
| **Good** | Flat network with no redundancy or ring structure. A single switch failure could result in a plant failure or automatic switchover to manual mode. The switch(es) are current technology. At minimum, there is a redundant power supply and a firewall, if there is a business network or Internet connection. | **7- 8** |
| **Fair** | Flat network with no redundancy or ring structure. A single switch failure could result in a plant failure or automatic switchover to manual mode. The switch(es) are not current technology and/or there are no redundant power supplies. If there is a business network or Internet connection, a firewall is installed. | **5 - 6** |
| **Poor** | A single switch failure could result in a plant failure or automatic switchover to manual mode. Obsolete network components and/or no firewall even if there is a business or Internet connection. | **2 - 4** |
| **Unacceptable** | No networking at all. Each unit is stand alone and there are no communications. | **0 - 1** |

| Chart 5 Hardware Assessment: Historical Archiving & Reporting | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Full stand alone system to collect historical data. The system is of current technology. Historical data is available to both the operator and to central control. Long term data storage and off-site backup built into the system. | **9 - 10** |
| **Good** | Full stand alone system to collect historical data. The system is not current technology. Historical data is available to both the operator and to central control. Long term data storage and backup built into the system. | **7- 8** |
| **Fair** | Limited historical data collection. The system may or may not be current technology. Historical data is not available to both the operator and to central control. Long term storage is archived. | **5 - 6** |
| **Poor** | There is limited historical archiving. The ability to do annual comparisons and long term data analysis is not possible. | **2 - 4** |
| **Unacceptable** | There is no historical archiving. | **0 - 1** |

| Chart 6 Software Implementation: PLC or RTU or Controller | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Software in controller(s) fully controls the plant including supervisory optimized inputs from a central control.<br>Score 9 if it meets above.<br>Add 1 if controller configuration software is current release. | **9 - 10** |
| **Good** | Software in controller(s) fully controls the plant, but does not have optimized supervisory control. It can however be operated remotely from a central control.<br>Score 7 if it meets above.<br>Add 1 if controller configuration software is current release. | **7- 8** |
| **Fair** | Software in controller(s) fully controls the plant, but does not have optimized supervisory control and it cannot be operated remotely from a central control.<br>Score 5 if it meets above.<br>Add 1 if controller configuration software is current release. | **5 - 6** |
| **Poor** | Software in controller(s) has limited control functionality. Its primary function is monitoring with little control. Software is not obsolete. | **2 - 4** |
| **Unacceptable** | Software in controller(s) has limited control functionality. Its primary function is monitoring with little control. Software is obsolete. Also score a 0 if source configuration software is missing. | **0 - 1** |

| Chart 7 Software Implementation: HMI (Human Machine Interface) | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The HMI has access to all control points. The HMI is easy to navigate and read. The operator is comfortable with the HMI. The vendor software is at a current release version or at a version supported by the vendor. The alarms are optimized. The alarms have clear information for operator action. The sequence of events (first out alarms) are clear and quick to access. | **9 - 10** |
| **Good** | The HMI has access to all control points. The HMI is easy to navigate and read. The operator is comfortable with the HMI. The vendor software is at a current release version or at a version supported by the vendor. The alarms are not optimized. There is a sequence of events alarm. | **7- 8** |
| **Fair** | The HMI has access to all control points. The HMI may not be easy to read or navigate. The operator may not be comfortable with the HMI or the vendor software is not at a current release version or at a version supported by the vendor. The alarms are not optimized. There is no sequence of events alarm. | **5 - 6** |
| **Poor** | The HMI has access to most control points. The HMI may not be easy to read or navigate. The operator may not be comfortable with the HMI or the vendor software is not at a current release version or at a version supported by the vendor. The displays or alarms are out of date. There are many points that are not valid or not functioning. The alarms are not optimized. | **2 - 4** |
| **Unacceptable** | The HMI and alarming are minimal. | **0 - 1** |

| Chart 8 Software Implementation: Data Server or SCADA | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The software is a current release version and the PC has a currently vendor supported operating system. All points (via a driver or directly) are available. All alarm points are accurately defined. Tags or points are accurately described. Data is fast(minimal lag time, average less than 1 sec to an HMI and/or output to a controller) | **9 - 10** |
| **Good** | The software is a current release version and the PC has a currently vendor supported operating system. All points (via a driver or directly) are available. All alarm points may not all be accurately defined. Tags or points may not all be accurately described. Data is fast (minimal lag time to an HMI and/or output to a controller). | **7- 8** |
| **Fair** | The software may be an older release version though the PC has a currently vendor supported operating system. All points (via a driver or directly) are available. All alarm points may not all be accurately defined. Tags or points may not all be accurately described. Data is slow (lag time to an HMI and/or output to a controller is high > 1 sec). | **5 - 6** |
| **Poor** | The software and/or the operating system may be obsolete. All points (via a driver or directly) may not be available. All alarm points may not all be accurately defined. Tags or points may not all be accurately described. Data rate may be acceptable. | **2 - 4** |
| **Unacceptable** | The software and/or the operating system may be obsolete. All points (via a driver or directly) may not be available. All alarm points may not all be accurately defined. Tags or points may not all be accurately described. Data rate is unacceptable. | **0 - 1** |

| Chart 9 Software Implementation: LAN – Process Control Network | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Managed switches are configured to optimize communications. Firewall and/or DMZ is programmed to protect the network. Bandwidth is optimized if there is high volume. Network diagnostics are available to the operator and/or to central control. | **9 - 10** |
| **Good** | Managed switches are configured to optimize communications. Firewall and/or DMZ is programmed to protect the network. Bandwidth is optimized if there is high volume. There is little network diagnostics available to the operator and/or to central control. | **7- 8** |
| **Fair** | Managed or unmanaged switches are used and with no configuration. Firewall and/or DMZ is programmed to protect the network. There is little network diagnostics available to the operator and/or to central control. | **5 - 6** |
| **Poor** | Managed or unmanaged switches are used with no configuration and no diagnostic capability of any kind. Firewall and/or DMZ are minimal. | **2 - 4** |
| **Unacceptable** | No networking at all. Each unit is unique and there are no communications. | **0 - 1** |

| Chart 10 Software Implementation: Historical Archiving & Reporting | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The software is a current version and easily used. Data can be accessed that is several years old to compare to current operations. Excellent reporting capabilities. Data is available at both central control and the local operator. | **9 - 10** |
| **Good** | The software is a current version and easily used. Data can be accessed that is several years old to compare to current operations. Data is not widely available as archiving is only in one location. | **7- 8** |
| **Fair** | The software may be an older version and no longer vendor supported. Data can be accessed that is several years old to compare to current operations. Data may not be widely available as archiving may only in one location. | **5 - 6** |
| **Poor** | The software may be an older version and no longer vendor supported. Data can NOT be accessed that is several years old to compare to current operations. Data may not be widely available as archiving may only in one location. | **2 - 4** |
| **Unacceptable** | There is no historical archiving. | **0 - 1** |

| Chart 11Security: PLC or RTU or Controller | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | Controller is protected from unauthorized access by a strong password and/or key switch. The controller is physically secured in a locked room or cabinet. All ports and services are minimized where there are Ethernet communications. | **9 - 10** |
| **Good** | Controller is protected from unauthorized access by a strong password and/or key switch. The controller may be easily physically accessed. All ports and services may not be minimized where there are Ethernet communications. | **7- 8** |
| **Fair** | Controller is protected from unauthorized access by a strong password and/or key switch. The controller may be easily physically accessed. All ports and services have not been tested where there are Ethernet communications. | **5 - 6** |
| **Poor** | Controller is protected from unauthorized access by password only. The passwords are easily guessed. The administrative password is still the default vendor password. The controller may be easily physically accessed. All ports and services have not been tested where there are Ethernet communications. | **2 - 4** |
| **Unacceptable** | There is no observable nor documented security of the controller. | **0 - 1** |

| Chart 12 Security: HMI (Human Machine Interface) | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The computer has all anti-virus, software patches, operating system and vendor security patches at current released versions. The computer is accessed via a strong password. There are no default administrator passwords. Ports and services have been evaluated and minimized. The computer runs in an operator mode - never in an administrator mode. | **9 - 10** |
| **Good** | The computer has all anti-virus, software patches, operating system and vendor security patches at current released versions. The computer is accessed via a strong password. There are no default administrator passwords. Ports and services have NOT been evaluated and minimized. The computer runs in an operator mode - never in an administrator mode. | **7- 8** |
| **Fair** | The computer may not have all anti-virus, software patches, operating system and vendor security patches at the current released versions. The computer may be accessed with an easily guessed password. There are no default administrator passwords. Ports and services have NOT been evaluated and minimized. | **5 - 6** |
| **Poor** | The computer may not have all anti-virus, software patches, operating system and vendor security patches at the current released versions. The computer may be accessed with an easily guessed password. Administrator password defaults are still intact. Ports and services have NOT been evaluated and minimized. The computer may run in administrator mode. | **2 - 4** |
| **Unacceptable** | There appears to be little security enabled or poorly updated. | **0 - 1** |

| Chart 13 Security: Data Server or SCADA | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The computer has all anti-virus, software patches, operating system and vendor security patches at current released versions. The computer is accessed via a strong password. There are no default administrator passwords. Ports and services have been evaluated and minimized. The computer runs in an operator mode - never in an administrator mode. Image backups are made on a regularly scheduled basis. | **9 - 10** |
| **Good** | The computer has all anti-virus, software patches, operating system and vendor security patches at current released versions. The computer is accessed via a strong password. There are no default administrator passwords. Ports and services have NOT been evaluated and minimized. The computer runs in an operator mode - never in an administrator mode. Image backups are made on a regularly scheduled basis. | **7- 8** |
| **Fair** | The computer may not have all anti-virus, software patches, operating system and vendor security patches at the current released versions. The computer may be accessed with an easily guessed password. There are no default administrator passwords. Ports and services have NOT been evaluated and minimized. Image backups are made on a regularly scheduled basis. | **5 - 6** |
| **Poor** | The computer may not have all anti-virus, software patches, operating system and vendor security patches at the current released versions. The computer may be accessed with an easily guessed password. Administrator password defaults are still intact. Ports and services have NOT been evaluated and minimized. The computer may run in administrator mode. There may not be image backups. | **2 – 4** |
| **Unacceptable** | There appears to be little security enabled or poorly updated. | **0 – 1** |

| Chart 14 Security: LAN - Process Control Network | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | All LAN device(s) configuration is protected by a strong password. The firewall and other LAN devices that support syslogs have logs sent to a syslog server and the logs are regularly evaluated. There are no default passwords on any device. | **9 – 10** |
| **Good** | All LAN device configuration is protected by a strong password. There may not be any network logging. There are no default passwords on any device. | **7- 8** |
| **Fair** | LAN device configuration is protected by an easily guessed password. There may not be any network logging. There are no default passwords on any device. | **5 – 6** |
| **Poor** | LAN device configuration is protected by a simple to guess password. There may not be any network logging. Default passwords may be on a device. | **2 – 4** |
| **Unacceptable** | There appears to be little security enabled or poorly updated. | **0 – 1** |

| Chart 15 Security: Historical Archiving & Reporting | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The computer has all anti-virus, software patches, operating system and vendor security patches at current released versions. The computer is accessed via a strong password. There are no default administrative passwords. Ports and services have been evaluated and minimized. The computer runs in an operator mode - never in an administrator mode. Image backups are made on a regularly scheduled basis. Tapes or disks are made regularly of historical data and saved in a secure storage. | **9 - 10** |
| **Good** | The computer has all anti-virus, software patches, operating system and vendor security patches at current released versions. The computer is accessed via a strong password. There are no default administrative passwords. Ports and services have NOT been evaluated and minimized. The computer runs in an operator mode - never in an administrator mode. Image backups are made on a regularly scheduled basis. Tapes or disks are made regularly of historical data and saved in a secure storage. | **7- 8** |
| **Fair** | The computer may not have all anti-virus, software patches, operating system and vendor security patches at the current released versions. The computer may be accessed with an easily guessed password. There are no default administrative passwords. Ports and services have NOT been evaluated and minimized. Image backups are made on a regularly scheduled basis. | **5 - 6** |
| **Poor** | The computer may not have all anti-virus, software patches, operating system and vendor security patches at the current released versions. The computer may be accessed with an easily guessed password. Administrative passwords defaults are still intact. Ports and services have NOT been evaluated and minimized. The computer may run in administrator mode. There may not be image backups. | **2 - 4** |
| **Unacceptable** | There appears to be little security enabled or poorly updated. | **0 - 1** |

| Chart 16 Hardware Assessment: Condition Monitoring | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | All or the majority of the following items are installed:<br>Turbine: 2-axis guide bearing vibration, guide bearing temperature, draft tube vibration, speed, seal ring position, wicket gate position.<br>Generator: air gap, 2-axis guide bearing vibration, guide bearing temperatures, thrust bearing oil film thickness, end winding vibration, core vibration, stator frame vibration, thrust bearing pad vibration, thrust bearing pad temperatures, generator winding temperatures, partial discharge probes, and cooling water flow.<br>All signals wired back to a control system. | **9 - 10** |
| **Good** | Majority of the above items are installed, but does not have partial discharge analysis:<br>All signals wired back to a control system. | **7- 8** |
| **Fair** | Majority of the above items are installed, but does not have partial discharge analysis and/or does not have all signals wired back to a control system: | **5 - 6** |
| **Poor** | Only some of the above items are installed and/or does not have all signals wired back to a control system: | **2 - 4** |
| **Unacceptable** | There is minimal amount of the above installed and not wired back to a control system. | **0 - 1** |

| Chart 17 Software Implementation: Condition Monitoring | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The probes are installed as listed in the hardware implementation. The control system will automatically trip on all abnormal conditions including partial discharge analysis. | **9 - 10** |
| **Good** | The probes are installed as listed in the hardware implementation. The control system will automatically trip on all abnormal conditions but does not have partial discharge analysis. | **7- 8** |
| **Fair** | The probes are installed as listed in the hardware implementation. The control system will automatically trip on some abnormal conditions and requires operator decision making on some abnormal conditions. | **5 - 6** |
| **Poor** | The probes are installed as listed in the hardware implementation. The control system does not automatically trip on abnormal conditions. The probes that are installed are viewable on the HMI. | **2 - 4** |
| **Unacceptable** | The probes are installed as listed in the hardware implementation. The control system does not automatically trip on abnormal conditions. The probes that are installed are NOT viewable on the HMI. | **0 - 1** |

| Chart 18 Security: Condition Monitoring | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **Excellent** | The probes are installed as listed in the hardware implementation. The condition monitoring system (usually separate from the controller) is on a protected network or isolated from the network by hard wires back to a control system. The vibration system is protected from accidental configuration changes by a key or a strong password. | **9 - 10** |
| **Good** | The probes are installed as listed in the hardware implementation. The condition monitoring system (usually separate from the controller) is on a protected network or isolated from the network by hard wires back to a control system. The vibration system is NOT protected from accidental configuration changes by a key or a strong password. | **7- 8** |
| **Fair** | NA | **5 - 6** |
| **Poor** | The probes are installed as listed in the hardware implementation. The condition monitoring system (usually separate from the controller) is NOT on a protected network and NOT isolated from the network by hard wires back to a control system. The vibration system is protected from accidental configuration changes by a key or a strong password. | **2 - 4** |
| **Unacceptable** | The probes are installed as listed in the hardware implementation. The condition monitoring system (usually separate from the controller) is NOT on a protected network and NOT isolated from the network by hard wires back to a control system. The vibration system is NOT protected from accidental configuration changes by a key or a strong password. | **0 - 1** |

Data Quality – Rating Criteria for Automation System Parts

Qualified personnel should make a subjective determination for the Data Quality scores, considering as many factors as possible. The suggested criteria for scoring the Data Quality of Automation System components are developed in Chart 19.

| Chart 19 Automation System Data Quality Rating Criteria | | |
|---|---|---|
| **Condition Description** | | **Score** |
| **High** | 1.) Vendor or plant configuration documentation at the site or at engineering is excellent including all security and able to physically see all components.<br>2.) Able to view controller, HMI, SCADA in real time for data - CPU loading, tags, memory etc. where practical. This data can be obtained from local support if they can provide the documentation without going online.<br>Condition monitoring viewable in real time.<br>LAN analysis documentation or real time analysis is demonstrated.<br>Historical data is viewable.<br>3.) Local engineering or tech support available at the site while doing the assessment to document or verbally confirm all items. They can also confirm off-site questions.<br>4.) Vendor online tech support via web or phone to confirm items for current offerings and current support levels. | **8 - 10** |
| **Medium** | Unable to have all 4 items above (where applicable), but a high level of confidence in the accuracy of the data. | **5 - 7** |
| **Low** | Unable to have 2 or more items above (where applicable). Made some assumptions on the system without firm documentation or plant confirmation or vendor confirmation. | **3 - 4** |
| **Poor** | Limited or no vendor documentation. No local engineering support available to confirm and no online verification able to be performed. | **0 - 2** |

| Chart 20 Instruments for Unit Performance Measurement: Physical Condition Rating Criteria | | |
|---|---|---|
| **Physical Condition Rating Scale** | | **Physical Condition Score** |
| **Excellent** | No noticeable defects. Some aging or wear may be noticeable. Display is easy to read and in a visible location for the operator. Clean and clear faceplate - either analog or digital. Pointer condition and indication is correct for operating point. | **9 – 10** |
| **Very good** | Only minor deterioration or defects are evident, and is fully functional. | **7 – 8** |
| **Good** | Some deterioration or defects are evident, but function is not significantly affected. | **5 – 6** |
| **Fair** | Only moderate deterioration and function is still adequate. The unit efficiency may be affected. | **3 – 4** |
| **Poor** | Serious deterioration in at least some portions, function is inadequate, unit efficiency or availability significantly affected. Meter is in a poor location for the operator. | **2** |
| **Very poor** | Extensive deterioration. Barely functional. | **1** |
| **Failed** | No longer functions, may cause failure of a major component. | **0** |

| Chart 21 Instruments for Unit Performance Measurement: Age Rating Criteria | |
|---|---|
| **Ages of the Metering Components** | **Age Score** |
| <5 years | **10** |
| 5-10 years | **8 - 9** |
| 11-15 years | **6 - 7** |
| 16-20 years | **4 - 5** |
| 21-25 years | **2 - 3** |
| 26-35 years | **0 - 1** |

| Chart 22 Instruments for Unit Performance Measurement: Technology Rating Criteria | |
|---|---|
| **Technology Levels of the Components/Items** | **Score for Installed Technology Level** |
| The technology has not changed significantly since the part was installed; and the installed technology was supplied by brand name companies with great reputations. Has digital or high resolution[1] inputs and displays. | **8 – 10** |
| The technology has been more or less advanced but no problem is foreseen to supply the matching parts in next 5-10 years, or the technology change has little effect on the efficiency and reliability of power generation (but may be less than the cost of replacement). The installed technology was supplied by medium companies with good reputations. | **4 – 7** |
| The installed technology has been phased out, it is a problem to supply parts in reasonable order time, or the technology change has significantly improved the efficiency and reliability of power generation. The installed technology was supplied by small companies with bad reputations. | **0 – 3** |

*1 - Low resolution inputs use 12 bit Analog to Digital converters. High resolution inputs are 13 bit or higher or use digital (serial) inputs. Older mechanical systems that do not have electrical feedback or metering, should still have vendor support for a high ranking.

| Chart 23Instruments for Unit Performance Measurement: Operating Restrictions Rating Criteria | |
|---|---|
| **Operating Restrictions or Off-Design Conditions** | **Score for Operating Restrictions** |
| The design standard has no changes and the original metering design has no constraints on the required operation. | **8 – 10** |
| The design standard has no changes and the original metering design has no constraints on the required operation. Newer technology offers more options that could be useful to the operation. | **5 – 7** |
| Moderate restraints: The quality of the data may be suspect. Newer technology offers better quality, but the system still functions with the known limitations. | **3 – 4** |
| Severe limitations: The data quality is unknown or highly suspect. Operations may be required at times to use alternate methods that may bypass the meter reading to verify values. | **0 – 2** |

| Chart 24 Instruments for Unit Performance Measurement: Maintenance Requirement Rating Criteria | |
|---|---|
| **Amounts of Corrective Maintenance** | **Maintenance Requirement Score** |
| Minimum level (normal condition): A small amount of routine recalibration or verification of data is required. | **9 – 10** |
| Low level: A small amount of routine recalibration or verification of data is required. Repairs could be completed during a unit preventive maintenance outage that is scheduled on a periodic basis. | **7 – 8** |
| Moderate level: Some corrective maintenance that causes extensions of unit preventative maintenance outages is required (e.g., faulty signals, rewiring). | **4 – 6** |
| Significant/Extensive level: Significant additional and corrective maintenance is required; forced outage occurs and outages are extended due to maintenance problems (e.g., failed instruments, faulty wiring, hard wired trips fail to function). | **0 – 3** |

Data Quality – Rating Criteria for Instruments for Unit Performance Measurement (Metering)

Qualified personnel should make a subjective determination for the Data Quality scores, considering as many factors as possible. The suggested criteria for scoring the Data Quality of Instruments for Unit Performance Measurement components are developed in Chart 25. Note the scoring method is different from Chart 19 for Automation System.

| Chart 25 Instruments for Unit Performance Measurement: Data Quality Rating Criteria | |
|---|---|
| **Data Availability, Integrity and Accuracy** | **Data Quality Score** |
| High – The metering maintenance policies and procedures were followed by the plant and the routine inspections, tests and measurement were performed within normal frequency in the plant. The required data and information are available to the assessment team through all means of site visits, possible visual inspections and interviews with experienced plant staff. | **8 – 10** |
| Medium – One or more of routine inspections, tests and measurement were completed 6-24 months past the normal frequency, or small portion of required data, information and documents are not available to the assessment team. | **5 – 7** |
| Low – One or more of routine inspections, tests and measurement were completed 24-36 months past the normal frequency, or some of results are not available. | **3 – 4** |
| Very Low – One or more of required inspections, tests and measurement were completed >36 months past the normal frequency, or significant portion of results are not available. | **0 – 2** |

## 6.0 I&C System Condition and Data Quality Indicators

In Table 1, the final condition score of the Automation System, i.e., the Condition Indicator, *CI*, can be calculated as follows:

$$CI(1) = \frac{\sum_{K=1,M}^{J=1,3} S_C(K,J) \times F(K) \times F(J)}{\sum_{K=1,M}^{J=1,3} F(K) \times F(J)} \qquad (1)$$

The I&C for Automation Data Quality Indicator, *DI*, will be the weighted summation of all Data Quality scores received for its associated components:

$$DI(1) = \frac{\sum_{K=1,M} S_D(K) \times F(K)}{\sum_{K=1,M} F(K)} \qquad (2)$$

Here *M* = the total number of components associated with an Automation System; *K* = the identification No. of automation components (from 1 to *M*); *J* = the identification No. of condition parameters (from 1 to 3, respectively for hardware, software and security); $S_C(K, J)$ = the condition score of an Automation System component for one of 3 condition parameters; $S_D(K)$ = the data quality score for a component; $F(J)$ = the weighting factor for a condition parameter; $F(K)$ = the weighting factor for a component.

In Table 2, the final condition score of the Instruments for Unit Performance Measurement, i.e., the Condition Indicator, *CI*, can be calculated as follows:

$$CI(2) = \frac{\sum_{K=1,M}^{J=1,5} S_C(K,J) \times F(K) \times F(J)}{\sum_{K=1,M}^{J=1,5} F(K) \times F(J)} \qquad (3)$$

The I&C for Automation Metering Data Quality Indicator, *DI*, will be the weighted summation of all Data Quality scores received for its associated components:

$$DI(2) = \frac{\sum_{K=1,M} S_D(K) \times F(K)}{\sum_{K=1,M} F(K)} \qquad (4)$$

Here *M* = the total number of components associated with Instruments for Unit Performance Measurement; *K* = the identification No. of metering components (from 1 to *M*); *J* = the Identification No. of condition parameters (from 1 to 5, respectively for physical condition, age, installed technology, operating restrictions and maintenance requirements);$S_C(K, J)$ = the condition score of an Automation Metering component for one of 5 condition parameters; $S_D(K)$ = the data quality score for a component; *F*(*J*) = the weighting factor for a condition parameter; *F*(*K*) = the weighting factor for a component.

The overall I&C system condition indicator (*CI*) will be weighted summation from automation and metering::

$$CI=CI(1)*0.8+CI(2)*0.2 \qquad (5)$$

The overall I&C system data quality indicator (DI) will be:

$$DI=DI(1)*0.8+DI(2)*0.2 \qquad (6)$$

## 7.0 Reference

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