OBJECTIVES FOR ALL REMAFEX FUNCTIONS

FUNCTIONS SPECIFIED BY EFI

S1 Trend analysis on insulation systems
S2 Monitor stator winding condition
S3 Monitor circuit-breaker operating mechanism condition
S4 Monitor hydraulic string and turbine condition
A3 Compute optimal mainenance interval

S1 Trend analysis on insulation systems

The function provides early fault indication for high voltage apparatus (HV apparatus) in power plants by measuring partial discharge trends.

Detection of failure and ageing in insulation systems as soon as possible will allow for optimisation of repair. It may avoid failures or reduce the effect of destruction of insulation strength that can constitute a hazard to operation of a power plant and to human life.

The monitoring system shall present trend values of partial discharge (PD) levels within all three phases for HV apparatus that are to be monitored. The system shall detect changes in the discharge intensity and sudden changes in discharge levels may cause alarms to be activated. Differences in the discharge intensity between the phases shall be used to indicate a failure under evolution.

S2 Monitor stator winding condition

The function reveals need for maintenance on stator winding insulation by recording phase resolved discharge patterns. The information can be used to recognise different defect types (i.e. end-winding discharge, loose bars etc) in stator windings of hydro generators and trend their developments.

Early detection of failure and ageing in the stator winding insulation system will allow for optimisation of repair. It may avoid failures that can constitute a hazard to operation of a power plant and to human life.

The recording system and software tools (MMT) shall acquire and present partial discharge (PD) signatures from the stator windings.

S3 Monitor circuit-breaker operating mechanism condition

The function interfaces an MMT (Maintenance Monitoring Tool) that monitors the mechanical condition of the operating mechanism of the generator circuit-breaker in a power plant.

The monitoring is performed by considering the mechanical vibrations generated when the breaker is operated. The vibration patterns or «signatures» are compared with a reference, e.g. a recording from a previous breaker operation. If deviations occur, this signifies that the mechanical condition of the device has changed, indicating that further examinations, inspections or maintenance should be carried out.

S4 Monitor hydraulic string and turbine condition

This function provides condition monitoring of the hydraulic string and turbine(s) of hydro power plants.

The condition in this context is defined as a set if hypotheses containing normal condition or one single «fault», i.e. either a process fault or a measurement device error.

Process faults are presented as a change in numerical value of one of the loss coefficients or the efficiency of the turbine. Measurement device errors are presented as a change of numerical value of the bias of a sensor (i.e. different from zero).

A3 Compute optimal mainenance interval

This function provides calculations of optimal maintenance intervals for hydraulic string, turbine and generator. This tool will contribute in the planning process to make better decisions for maintenance and refurbishment by combining economical assumptions and evaluations with the technical state of the power production system.

The system provides documentation for decisions and will give the maintenance planner a tool, which speaks the important language of economy. Based on current knowledge, the planner can say that this recommended solution is the correct maintenance/refurbishment decision for the system being analysed. The model will calculate the expected maintenance cost following an optimal strategy, and also document the «invisible» costs of running the system at a lower efficiency level than a newly maintained/refurbished system would.

FUNCTIONS SPECIFIED BY EDP

S6 Compute MSV (turbine efficiency)
S9 Compute MSV (guide vanes clearance)
F1 Perform trend analysis of MSV (turbine efficiency)
F25 Perform trend analysis of MSV (guide vane clearance)
D1 Identify and display fault localisation
A5 Quantify failure value
A6 Analyse and display consequences of failure to the system

S6 Compute MSV (turbine efficiency)

The function objective is to assess the loss in efficiency and/or power of the machine resulting from wear, through a test programme including several operating points within the normal working range. In addition, it may be useful for other purposes, such as to assess the change in efficiency after repair or modification and due to the onset of cavitation resulting from a change of suction specific potential energy and/or specific hydraulic energy.

S9 Compute MSV (guide vanes clearance)
F25 Perform trend analysis of MSV (guide vane clearance)

The function objectives are to reveal the actual guide vanes clearance condition resulting from wear due to silt or other abrasive content in water and to forecast clearance degradation (in terms of the remaining operating hours).

F1 Perform trend analysis of MSV (turbine efficiency)

The function objective is to reveal the turbine efficiency degradation resulting from wear due to cavitation and/or abrasion, allowing the maintenance operator to forecast (schedule) runner repairs, taking into account the previous operating conditions and the expected ones. Runner excessive degradation can ultimately cause damage to the rest of the hydraulic machine.

The function performs trends of efficiency historical data of similar operating conditions, since efficiency values are dependent on operating conditions of power plant.

So, a previous step will be to establish classes of operating heads and guide vanes openings (or power values) and to classify the operating hours accordingly, that is, to set up a statistical distribution of operating hours.

D1 Identify and display fault localisation

The function provides the identification of the faulty sub-item at the appropriate indenture level (subsystem, component,...).

A5 Quantify failure value
A6 Analyse and display consequences of failure to the system

The function(s) provides the failure value quantification (which reveals the ability of the faulty sub-item to perform its function), and system (subsystem) state caused by the faulty sub-item.

The functions task is to quantify the failure value in accordance with IEC 50-191-04 and to evaluate the final state of the system and subsystem, from the incidents inventory table.

FUNCTIONS SPECIFIED BY IBERDROLA (I)

S22 Detect dissipated energy in refrigeration coil
S23 Determinate dirt level in refrigeration coils
F8 Detect probability of future thrust bearing distrubances
F9 Detect probability of future gererator guide bearing distrubances
F10 Detect probability of future breaking system disturbances
F13 Detect probability of future turbine guide bearing disturbances

S22 Detect dissipated energy in refrigeration coil

The objective of the function is to calculate and report the dissipated energy in any of the refrigeration coils of the plant. This way we can calculate the real heating of the item under observation, independently from the incoming water flow and temperature.

For this purpose, we will define the model that describes the relationship between the water flow inside the coil, the temperature variation the water suffers and the resulting dissipated energy.

S23 Determinate dirt level in refrigeration coils

The objective of the function is to detect and report the refrigeration coils obstruction level that can produce a future malfunction .

For this purpose, we will define an empirical model of the physical features of the refrigeration coils. Thus, following this model we will be able to determine in every moment the dirt level of the coils and to avoid non safety situations.

This information will be useful to evaluate the probability of some incidents.

F8 Detect probability of future thrust bearing distrubances

The objective of the function is to detect and report any anomalous event concerning the thrust bearing that can produce a future malfunction .

This objective is decomposed into another four functions corresponding to the micro needs associated to the macro need this function describes. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the four micro needs (incidents) ordered by the certainty factors associated to each incident.

The incidents relative to thrust bearing malfunction are:

_ Parasite current through thrust bearing

_ Upper carter oil leakage

_ Babbit metal wearing in thrust bearing

_ Injection failure

This information will be enough for the expert to take a decision about the preventive maintenance of the plant in a concrete item (thrust bearing).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

F9 Detect probability of future gererator guide bearing distrubances

The objective of the function is to detect and report any anomalous event concerning the generator guide bearings that could produce a future malfunction.

This objective is decomposed into another six functions corresponding to the micro needs associated to the macro need described by this function. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the six micro needs (incidents) ordered by the certainty factors associated to each incident. The same six incidents are relative to upper and lower guide bearing possible malfunctions .

The incidents relative to generator upper guide bearing malfunction are:

_ Parasite current through generator upper guide bearing

_ Oil leakage in generator upper guide bearing

_ Water leakage to oil in generator upper guide bearing

_ Babbit metal wearing in generator upper guide bearing

_ Lack of cooling in generator upper guide bearing

_ Breaking of coolant coil in generator upper guide bearing

The incidents relative to generator lower guide bearing malfunction are:

_ Parasite current through generator lower guide bearing

_ Oil leakage in generator lower guide bearing

_ Water leakage to oil in generator lower guide bearing

_ Babbit metal wearing in generator lower guide bearing

_ Lack of cooling in generator lower guide bearing

_ Breaking of coolant coil in generator lower guide bearing

This information will be enough for the expert to take any action about the preventive maintenance of the plant in this concrete item (generator guide bearing).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

F10 Detect probability of future breaking system disturbances

The objective of the function is to detect and report any anomalous situation concerning the braking system that can produce a future malfunction .

This objective is decomposed into another seven functions corresponding to the micro needs associated to the macro need this function describes. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the seven micro needs (incidents) ordered by the certainty factors associated to each incident.

The incidents relative to braking system malfunction are:

_ Jacks wedging

_ Air leakage

_ Shoes wearing

_ Deformation / breaking of braking band

_ Braking jacks pistons scratching

_ Sudden braking with machine started

_ The machine does not stop

This information will be enough for the expert to take a decision about the preventive maintenance of the plant in a concrete item (braking system).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

F13 Detect probability of future turbine guide bearing disturbances

The objective of the function is to detect and report any anomalous event concerning the turbine guide bearing that could produce a future malfunction.

This objective is decomposed into another five functions corresponding to the micro needs associated to the macro need this function describes. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the five micro needs (incidents) ordered by the certainty factors associated to each incident.

The incidents relative to turbine guide bearing malfunction are:

_ Oil leakage in turbine guide bearing

_ Water leakage to oil in turbine guide bearing

_ Babbit metal wearing in turbine guide bearing

_ Lack of cooling in turbine guide bearing

_ Breaking of coolant coil in turbine guide bearing

This information will be enough for the expert to take any action about the preventive maintenance of the plant in this concrete item (turbine guide bearing).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

FUNCTIONS SPECIFIED BY IBERDROLA (II)

S27 Detect dissipated energy in rotating seal
S29 Calculate hydroelectric set, turbine and generator efficiency
S37 Detect rotor excitation power consumption
F3 Compute stator winding temperature
F11 Detect probability of future generator cooling system disturbances
F14 Detect probability of pelton turbine runner degradiations
F15 Detect probability of future regulation system disturbances
F17 Detect probability of francis turbine runner and seals degradations

S27 Detect dissipated energy in rotating seal

The objective of the function is to calculate and report the dissipated energy in water refrigeration of Francis runner seal. This way we can calculate the real heating of the item, independently from the incoming water flow and temperature.

For this purpose, we will define the model that describes the relationship between the water seal flow, temperature variation that the water suffers and the resulting dissipated energy.

S29 Calculate hydroelectric set, turbine and generator efficiency

The objective of the function is to calculate and report the hydroelectric set, turbine and generator efficiency, as well as cooling losses in turbine and generator and raw head losses in pipes for efficiency valuation.

For this purpose the function will estimate the real efficiencies of the different items of the installation (water gallery, forced pipe, branchs, turbine, generator) according to the plant instrumentation and they will be compared with the theoretical efficiencies showed by theoretical engineering calculations and efficiency curves supplied by manufacturers.

The real and theoretical efficiency discrepancy, as well as the different values calculated will be monitored and trending.

S37 Detect rotor excitation power consumption

The objective of the function is to report the excitation power and compare it with theoretical manufacturer excitation power consumption. In this function the excitation power curve will be registered and compared with the supplier curve in starting or stopping periods.

F3 Compute stator winding temperature

The objective of the function is to using the nine actual RTD sensors installed in generator stator (three per phase).

The objective of the function is to compute the different temperature values from stator winding sensors (nine sensors located inside three phase windings), and obtain one value represented by a fuzzy function.

F11 Detect probability of future generator cooling system disturbances

The objective of the function is to detect and report any anomalous event concerning the generator cooling system that could produce a future malfunction.

This objective is decomposed into another three functions corresponding to the micro needs associated to the macro need described by this function. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the following micro needs (incidents) ordered by the certainty factors associated to each incident.

The incidents relative to generator cooling system malfunction are:

_ Water leakage, breaking of coolant pipes and /or coils

_ Lack of water cooling system

_ Lack of ventilation air pressure

_ Air channels obstruction

This information will be enough for the expert to take any action about the preventive maintenance of the plant in this concrete item (generator cooling system).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

F14 Detect probability of pelton turbine runner degradiations

The objective of the function is to detect and report any anomalous event concerning the Pelton turbine runner that could produce a future malfunction.

This objective is the function corresponding to the micro need associated to the macro need described by this function. The final objective of this function will be to detect any malfunction from the results returned by the micro need function. Thus, the output of this function will be the only micro need (incidents) ordered by the certainty factors associated to the incident.

The incident relative to Pelton turbine runner malfunction is:

_ Hydraulic phenomena in runner (cavitation, oxidation, profile looses, erosion , cracks)

This information will be enough for the expert to take any action about the preventive maintenance of the plant in this concrete item (Pelton turbine runner).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

F15 Detect probability of future regulation system disturbances

The objective of the function is to detect and report any anomalous event concerning the regulation system that could produce a future malfunction.

This objective is decomposed into another fourteen functions corresponding to the micro needs associated to the macro need described by this function. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the fourteen micro needs (incidents) ordered by the certainty factors associated to each incident.

The incidents relative to regulation system malfunction are:

_ Oil pressure pump motor malfunction (Pelton and Francis)
_ Oil pressure pump malfunction (Pelton and Francis)
_ Bad oil aspiration in pump (Pelton and Francis)
_ Internal oil leakage (Pelton and Francis)
_ External oil leakage (Pelton and Francis)
_ Air leakage (Pelton and Francis)
_ Lack of cooling (Pelton and Francis)
_ Increase of stress in injection system (Pelton)
_ Excessive time in water closing , water leakage (Pelton)
_ Gaps in needles and deflector position (Pelton)
_ Increase of stress in guide vane system (Francis)
_ Leakage in vane closing (Francis)
_ Leakage in guide vane seal (Francis)
_ Gaps in guide vane system and in rudder (Francis)

This information will be enough for the expert to take any action about the preventive maintenance of the plant in this concrete item (regulation system).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

F17 Detect probability of francis turbine runner and seals degradations

The objective of the function is to detect and report any anomalous event concerning the Francis turbine runner and seals that could produce a future malfunction.

This objective is decomposed into another several functions corresponding to the micro needs associated to the macro need described by this function. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the micro needs (incidents) ordered by the certainty factors associated to each incident.

The incidents relative to Francis turbine runner and seals malfunction are:

_ Hydraulic phenomena in runner (cavitation, oxidation, profile looses, erosion, cracks)
_ Water leakage in runner seal
_ Runner seal heating
_ Friction in runner (interstice rings)
_ Water leakage in aeration system
_ Bad ventilation
_ Damage in stay vanes
_ Damage in draft tube

This information will be enough for the expert to take any action about the preventive maintenance of the plant in this concrete item (Francis turbine runner and seals).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.