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ANALYSIS OF COORDINATION AND SELECTIVITY BETWEEN PROTECTION DEVICES OF LOW VOLTAGE SYSTEM (440VAC)

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ABSTRACT

This study aims to analyze the coordination and selectivity of the protection in a low voltage industrial electrical installation, so that the protection devices isolate and eliminate the fault quickly and selectively. To achieve this objective, a survey of the installed loads was carried out, a conference of fuse values and adjustment of the thermal relays, verification of the gauge of the cables connecting the respective loads and calculations of the short-circuit current through a software. Therefore, we want to demonstrate the importance of the correct selection of protection equipment and the impact that it can cause in productivity when incorrectly designed, impacting the continuity of the electric power supply to the manufacturing process. The analyzes presented here are based on the IEEE 242 standard, coordination and selectivity reports, and authors such as Caminha, Mamede Filho, Hewitson and Mardegan. The study was carried out within a pulp and paper industry, which, because it was an old plant, some protective equipment had to be replaced by modern ones. For example, the fuse switches and the bimetallic relays were replaced by electronic thermal relays and motor circuit breaker, since the old equipment did not allow us to make the correct coordination and selectivity, while others were only adjusted to work accordingly with the nominal data of the motors information plates. in this way, the objective of adapting the coordinated and selective protection system for overload, short-circuit and blocked rotor disarms was reached.

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INTRODUCTION

Whether in generation, transmission, distribution, in your house or in the industry, the power grid is susceptible to disturbances and failures due to a number of internal and external factors. Thus it becomes impracticable to leave an electrical system operating without the necessary protections, because in the absence of these, malfunctions of the equipment can occur, discontinuity in the energy supply and, in more serious cases, accidents with people that can be fatal. In this way, it is imperative to install protection devices, which must be properly designed since they're purpose is to preserve the physical integrity of the electrical installation and the equipment connected to it, as well as the safety of the electric power system users (Negrão, 2015). Protection devices such as fuses, relays and circuit breakers must protect the entire electrical circuit, isolating only the under failure area, leaving all other circuits intact and ensuring continuity of electrical supply. These systems must detect failures, currents or abnormalities and operate correctly before irreparable damage occurs, thus avoiding unnecessary expenses with corrective maintenance and guarantee the safety of users (Caminha, 1977). Selectivity is a very important feature in a protection system because it's the protection ability to identify and locate a failure, disconnecting as few loads as possible to extinguish the fault. And coordination is the ability of the protective devices to cooperate, so the device closest to the failure acts faster and if that fails another one is triggered (Mardegan, 2012). In this work, the coordination and selectivity of protection devices against overload and short circuits failures were studied, where in order to coordinate a system with the proper protection performance, the selectivity of the electrical system is applied, in which the equipment that presents the failure will be sectioned from the circuit, by the closest protective device. With the Time x Current graph, generated by a specific software, it's possible to verify in which values of time and current a protection device can be activated. For each protection device, there will be a characteristic curve, where in some devices this curve is fixed. In contrast, the relays, especially the electronic ones, present a series of configurations and adjustments. It is extremely important that the characteristics of the equipment connected to the electrical system to be protected are known, in order to avoid that the protection devices interfere without necessity in the normal operation of the electric power supply. The plate data of an equipment provides the safe operation limits, which, if respected do not compromise the integrity of the equipment. If this information is not respected or it's criteria are dispensed the damages will be perceived in the material losses as burned engines, changed cables, hours of production stopped. The intention of this work is to define the necessary parameters for the equipment of an industrial plant to be correctly coordinated and selected for their respective protection devices.

Problem

The object of study in this work is an industrial plant that operates 24 hours a day, and it's electrical installations are exposed to all kinds of electrical disturbances, so it's of the utmost importance that the protection devices are dimensioned correctly and in perfect synchrony with coordination and selectivity, so that the plant does not stop it's activities. For this reason, a detailed study of how these devices will be triggered in the event of a failure was necessary.

Justification

In a globalized world where industries operate day and night, practically non-stop during all year round in a highly competitive market, safe and reliable electrical installations are vital to keep high productivity and low costs. In order to guarantee reliability, safety and that disturbances or failures in the electrical network do not affect the entire industrial plant, but only a specific point of the electrical circuit, it is necessary to study the coordination and selectivity among the protection devices, in order to eliminate unwanted interruptions.

Objectives

This study was based on the analysis of coordination and selectivity between the protection devices of the electrical circuits in an industrial plant. Aiming to demonstrate the importance of properly designed devices and how incorrectly choosing these protections affects the productivity of the industry. This will be done through the loads collected and the studies to be done with the graphs "Time x Current", with the aid of an specific software. With this study we seek to understand the types of failures and their effects on an industrial electrical system, to know the devices used for protection.

Methodology

This work was based on a case study, which presents real problems in a pulp and paper industrial plant. The information was collected through coordination and selectivity reports made by contracted company. Based on the studies carried out, the load protections that were studied on this work will be qualitatively improved, so that the failure affects a small area of the factory, generating the lowest possible losses.

Low Voltage Protection

All electrical power system projects, when designed, must supply enough electric power for the present loads, as well as to meet future installed loads according to the user's need (Americo *et al*., 2017). This way, the protection devices must protect the whole system, isolating possible failures and maintaining the supply continuity for the other loads. This minimizes repair costs and guarantees user safety. Such requirements are necessary for the immediate detection and localization of failures and defective equipment to be removed (Hewitson *et al*, 2004). But to perform such functions, the protection devices must have the following qualities: "Selectivity: To detect and isolate only defective equipment. Stability: To leave other circuits intact, ensuring continuity of supply. Sensitivity: To detect the smallest failures, currents or abnormalities in the system, operating correctly before the failure causes irreparable damage. Speed: To operate quickly when needed, minimizing damage to the environment and ensuring user safety. Reliable: Must disarm only when necessary. Safe: Do not disarm because of a false failure" (Hewitson *et al*, 2004). Therefore, in order to achieve the investment maximum return in protection for a power system, it's necessary to keep the system in continuous operation and with the minimum possible interruptions. Since creating a protection system that can eliminate all failures becomes expensive and unfeasible, a system that can determine the abnormalities and extinguish the failures as quickly as possible is adopted.

Coordination and Selectivity

The study of coordination and selectivity aims to determine the adjustments that activate only the protection device closest to where the failure occurs, be it transitory or permanent, in the shortest possible time. This way, the rest of the circuit continues in normal operation, protecting the other equipment arranged in this circuit from the failure effects (Mardegan, 2012). The study of coordination and selectivity is done with the help of the equipment "Time x Current" curves, that are part of the electric network protection system.

Current Selectivity

This type of selectivity procedure is based on the premise that failure currents increase as the failure approaches the source of the supply. It's particularly used in low voltage systems where the impedance of the conductors are very high between the points where selectivity is needed. In order for this selectivity to be satisfied, the protection upstream of the fault must be set lower than the short circuit current, while the protection outside the protected zone must be set higher than the short circuit current (Mamede Filho, 2001).

Chronological Selectivity

This procedure is based on the principle of timing the protection device that is closest to the failure with the time value lower than the device that is upstream of this device (Mamede Filho, 2001).

Logical Selectivity

This is done through the use of multifunction digital relays that allow the failure to be extinguished in very small periods of time, between 50ms and 100ms (Mardegan, 2012).

Coordination Intervals

It's the time interval that ensures the closest protection device to the short circuit will operate first, and that the device located upstream of the short circuit will not operate, unless the closest protection does not work.

Electric motors protection types

Thermal overload relay

Overload relays protect motors against improper heating in their windings when subjected to an overload or an occurrence of phase failure in the circuit, causing an increase in the motor current. With the current increase, the trigger mechanism that will act on the auxiliary contacts is activated and these turned off the motor through a contactor. The time to shutdown is related to the overload current and the current set in the relay, which is properly represented in the relay tripping curve (WEG, 2017). The triggering curve makes the ratio of current versus triggering time in the form of multiples of the set current for three-phase loads running cold. The limits for triggering are in the order of 105% to 120% of the adjustment current for three-phase loads. The curve is valid for triggering the relay when all three phases are under the same current intensity, prolonged exposure to this failure will result in damage to the motor. In order to avoid this occurrence, some thermal relays are equipped with a phase-loss sensor, which accelerates the actuation of the relay actuation mechanism, thus maintaining the appropriate characteristics of the triggering curve (WEG, 2017).

Electronic Overload Relay

They have the same function as the thermal overload relay, but they do not have mechanical parts for their operation, since they have microprocessors and electronic circuits specially developed for their operation. They can be applied to a wide range of industrial applications, even the heaviest ones with greater inertia and starting time. In this way, the same relay can be applied to different types of loads, since it's possible to change the class of actuation of the relay by means of *dipswitch* according to the necessary starting time.

Fuses

Device used to protect against short circuits. It's working principle is based on the foundry of the conductive element that interrupts the circuit when a current circulates above the one designed for the fuse (Mardegan, 2012).

According to DIN 57636 and VDE 0636 standards, fuses have as their main function the protection of equipment and cables acting as current limiters.

The IEC uses two letters to define the fuse class, where the first letter is the interruption range and the second is the use category. The first letter is defined as follows:

"g" Performance for overload and short circuit, interrupting capacity of fuses across the range;"
"A" Actuation only for short-circuit, fuses of partial-range interrupting capacity.

The second letter is defined as:

"L/G": Cables and Lines / General Purpose Protection
"M": Maneuver equipment
"R": Semiconductors
"B": Mines installations
"Tr": Transformers (IEC 60270, 2001).

They can also be classified as for the actuation speed. Ultrafast used to protect electronic circuits, semiconductor protection, where there can be no minimum current variation; Fast, also used in semiconductors with fast enough action to limit current increase; Normal, aims to protect electrical and electronic circuits, where there is no need for a short actuation time, usually used in low inductance circuits; Delayed, used for motor starters, where the fuse does not operate at the peak current caused by the starting current.

Thermistors

Thermal detectors, composed of semiconductors, where their resistance varies depending on the temperature variation, located inside the motor, can be PTC or NTC type. For the PTC type the temperature coefficient is positive, that is, when the winding temperature reaches a value higher than that projected the thermistor rapidly increases it's resistance, causing the opening of an auxiliary relay, disconnecting the motor from the circuit. For the NTC type, the temperature coefficient is negative, that is, when the winding temperature reaches a value higher than that projected, the thermistor reduces its resistance rapidly, causing the opening of an auxiliary relay, disconnecting the motor from the circuit (Mamede Filho , 2001).

Failures and Consequences

The types of failures that are taken into account in this work are related next.

Active Failures

The active failure is that which occurs between two conductors with potential difference, being either phase-phase or phase-earth type. This type of failure can be classified as either solid or incipient (Hewitson *et al*., 2004). The solid failure occurs when there is a rupture in the cable insulatione, as if a pick or a backhoe hit a gallery of underground cables, which could lead to the ocurrence of an electric arc (Hewitson *et al*., 2004). This type of failure must be extinguished as soon as possible, otherwise damage may occur at the failure location (Failure energy = $I^2 \times Rf \times t$, where "t" is measured in seconds). The delay in interrupting this type of failure causes danger to the operational personnel, an increase in the probability of the problem extending to the other phases, high mechanical and thermal stress due to high failure current, especially for transformers that suffer progressive deterioration of their windings because of large electromechanical forces, voltage drops, leading the industrial plant to instability or even shutdown. The incipient failures are transitory failures and become extinct alone, without the intervention of the protection system, and occur due to the natural aging process of the electrical insulation. These failures occur as small things and become large catastrophic failures (Hewitson *et al*, 2004).

Passive Failures

Passive failure is one or more conditions that are forcing the system beyond it's design capacity (Hewitson *et al*, 2004). Examples of passive faults are: overload leading to heating and deterioration of the insulation, decreasing it's useful life; Overvoltage leading the insulation beyond it's design capabilities; Low frequency causing plant malfunction; Power oscillation.

Transient and permanent failures

Transient failures are failures that don't compromise the circuit insulation and can be re-energized after a short period of time. An example would be an atmospheric discharge in an insulator that would be extinguished with the opening of the protection device, and soon after can be re-connected. Permanent failures, as the name says, results in damage to the insulation, in this case the system cannot be re-energized without replacing or repairing damaged equipment.

Symmetric and asymmetric failures

The symmetric failure is a balanced failure in the sine wave through it's time axis and represents a stationary situation. While the asymmetric fault exhibits a DC offset transient and descending to the symmetric steady state after a period of time (Hewitson *et al*, 2004).

Abnormal Engines Operating Conditions

The electric motors that move the industries are fundamental equipment so that a company, in it's diverse sectors, does not stop to produce. Therefore, when subjected to adverse conditions they must be isolated from the electric circuit in order to preserve their useful life and other parts of the circuit. We can divide these adversities into different types according to time and for each there is a specific type of protection.

Continuous Overload

According to Mamede Filho (2001), "the steady state of heating is generally achieved after a few hours of continuous operation, which guarantees them a useful life of at least twenty years. For each 10% additional heating, the engine useful life drops to 10 years." In other words, after a certain operating time the motors reach the temperature stability curve and tend to maintain a working temperature for a given service load to which it was designed. If there is a load increase or a sudden increase in the environment temperature, it's temperature will increase while decreasing it's useful life.

Intermittent Overload

It is valid for motors that constantly suffer starts and braking during the working period. The overload regime to which the motor is subjected must be known so that the protection is adjusted to not interfere with the operation of the motor and does not cause unexpected and unwanted shutdowns.

Reduction of voltage supply

Observing where the motor is installed and if there is a considerable voltage drop, below the normal conditions, the motor will be subjected to a load current increase, changing the characteristics of the items: "The starting torque decreases with the square of the applied voltage, the starting current falls proportionally with the reduction of the voltage, the full current load increases, the rotor current increases in the same ratio, the power factor increases, the stator and rotor losses also increase, heating the winding, the speed decreases, causing ventilation deficiency "(Mamede Filho, 2001).

High Voltage Supply

Observing where the motor is installed and if there is a considerable voltage increase, above the normal conditions, there will be change in the characteristics of the items: "The starting torque increases with the voltage square, the full load current decreases, the maximum torque increases with the square of the voltage, the power factor decreases, the rotor and stator losses decrease, the speed increases slightly, improving the conditions of heat exchange "(Mamede Filho, 2001). The electrical power system with great influence on low voltage secondary systems, studies and improvements in order to identify failures in the electrical system which is to cause problems of greater impact (Stefenon *et al*, 2015) (Stefenon *et al.*, 2017).

Blocked Rotor

This data is found in the motor manufacturer's datasheet where the maximum starting time and locked rotor minimum torque ensures that the physical characteristics of the motor windings will not change (Mamede Filho, 2001).

High Temperature Environment

In the case of a motor operating in an high temperature environment, above the projected and the motor ventilation cannot lower this temperature, forced ventilation would be an outlet, besides the use of thermistors or thermometers for the motor protection (Mamede Filho, 2001).

Deficient Circulation of the Circulating Medium

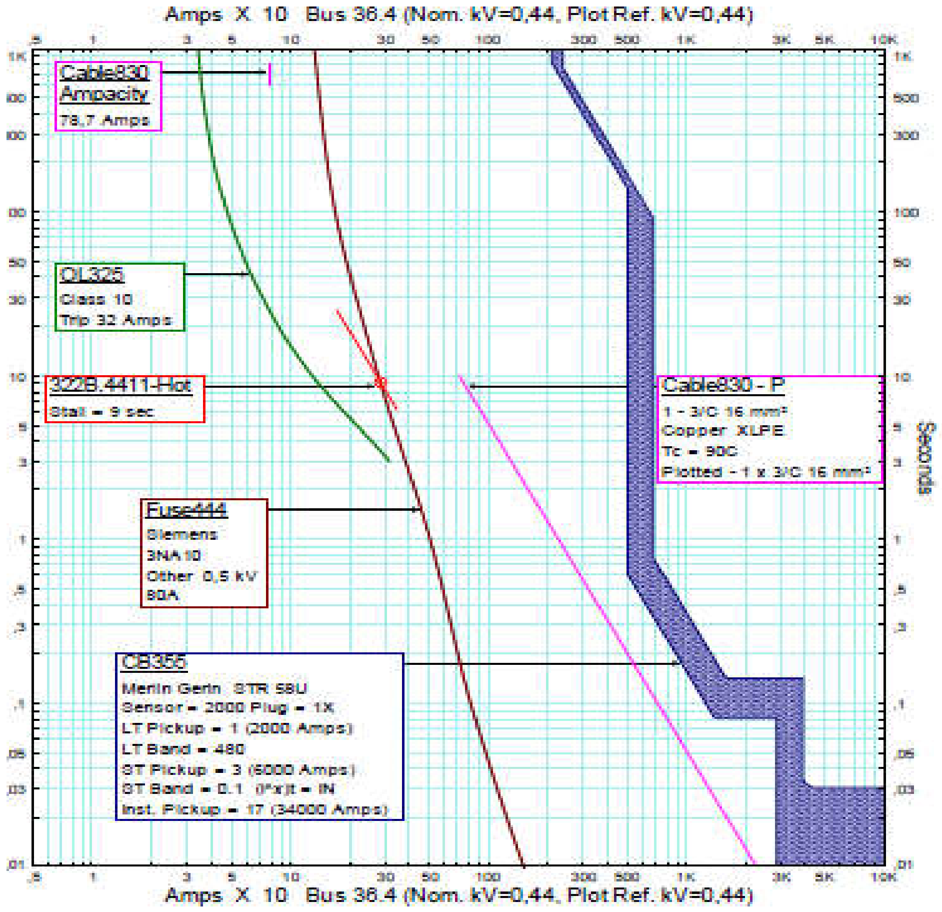
Absence or low natural ventilation or forced ventilation where the motor is operating.

Frequency Variation of the Network

This is unusual for normal operating distribution systems, but the set variation in frequency can change the characteristics of the motors. According to Mamede Filho (2001), "the power practically does not vary, the conjugate varies inversely with the frequency and the angular velocity and the losses vary in the same proportion". If the engine is subjected to a frequency below that established by the concessionaires, in the case of Brazil 60 Hz, there will be a decrease in speed, causing low ventilation and consequently heating ointhe motor windings. In this case it’s necessary to use thermistors or thermal probes.

Operating with Unbalanced Currents

Unbalanced phase currents cause negative thermal effects to the motor when is operating near or superior to the nominal load. Due to the pellicular current effect in the rotor bars, there is heating on the rotor due to the corresponding thermal dissipation. The stator is not damaged in this condition.



Source: Report ABtek, 2016

Figure 1. Graph Time x Current

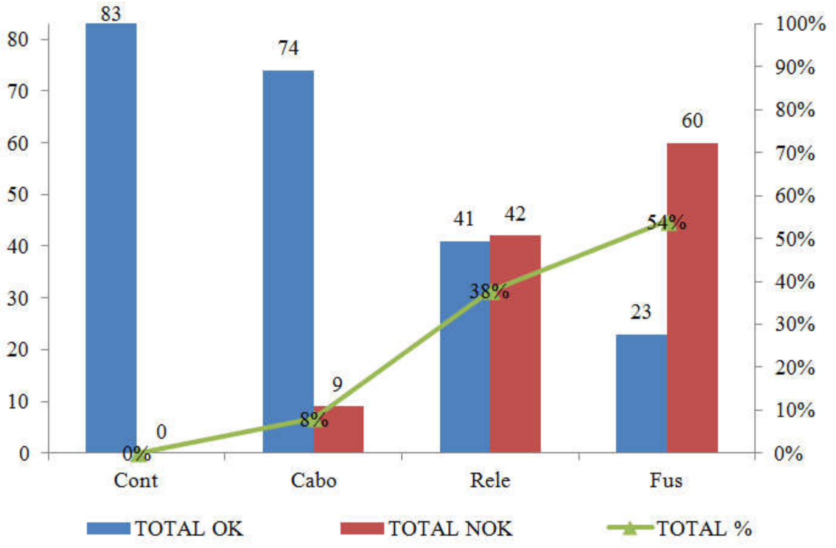


Figure 2. Pareto’s Graph

Protection through thermal relays or thermistors is not sensitized and the rotor temperature will exceed the limits for which it was designed and will eventually subject the motor to irrecoverable damage. The proper protection would be a phase balancing relay or phase reversal relay (Mamede Filho, 2001).

Operating without phase

Phase loss, caused by a defective circuit breaker or contactor, may result in damage to the motor windings as long as the protections do not work properly, whether it is connected in star or triangle. For the star-connected motor, if there is a phase loss, the current that will circulate between phase and line will be the same as the current that circulates the protection, in this way provides favorable conditions for the protection device actuation. For triangle-connected motors, the current distribution becomes more complex and depends on the nominal torque with which the motor works at the moment (Mamede Filho, 2001). The phase failure relay is the most indicated for this situation, since it's more safe to the motor, independent of the connection.

Coordination and Selectivity Analysis

A survey was carried out to verify if the protection and power conductors of the pumps, agitators and fans motors that were analyzed within the industrial plant under study were in agreement with coordination and selectivity. Motor plate data, fuses, thermal relays, cables and contactors were analyzed. This information was compiled into a table, which was passed to the ABtek company that entered this data into the ETAP 12.5.0C software. This software provides current X time graphs as result, used by ABtek company to report on the conditions of the protection system of facilities. Thus, the protections that were coordinated and selective were known, and with this, the study diagnosis of coordination and selectivity started. In Figure 1 graph we have an example of how the circuit is assembled with the data raised and how the software generates the current X time graph. Through this graph one can observe the conditions for the protection coordination. If the relays curves and fuses do or do not intercept, if the locked rotor time will not operate the fuses or relays, this is the required time to take the motor out of it's inertia. In addition, you can check if the time and class of the relays are correct, if the circuit cable is well protected, and check if the motor control center input breaker settings are correct.

The compiled table is presented in Appendix A, which lists the motors that were analyzed, giving information on power, number of poles, rated current, installed fuse, thermal relay setting range and for which current the fuse is set. Through this table we can analyze the coordination and selectivity before and after study. With this information, the pareto graph, Figure 2, was generated, which helped in the decision making of the most critical case, through which the adequacy activities would begin in the last months. It can be observed that the overall percentage of fuses that were in disagreement was 72%, 51% in relays and 11% in cables, in a total of 83 motors analyzed. Based on this information, adequate protection devices were specified and acquired, in order to adjust the coordination and selectivity of the protections. It's important to note that 40% of the analyzed motors are of extreme importance to the manufacturing process, and if there were any failures and the protections did not work properly, large losses could occur, such as burnt motors.

In addition, they are large and expensive equipment, where about 48% of these motors are pumps with power between 20 and 30 hp, that require a lot of time for aligning the motor shaft with the pump shaft. Cables are also damaged due to excessive exposure to heat, because of the non-action of a protection. It may cause open short circuit due to insulation failure, which takes time to fully exchange the cable. In an motor control center, improper protection can damage drawers with motor starters, due to excessive exposure to heat, their claws melt, they also generate a short circuit, where they must be exchanged or repaired, as the severity of the defect caused thereby. In addition to lost production time it could be hours or even days depending on the severity of the fault.

Conclusion

Over the course of approximately six months, activities were carried out, according to the priority of each motor, to adjust coordination and selectivity of the motor protection. During this time, the fuses were changed and the thermal relay settings were adjusted according to the motor nameplate data, ensuring the coordination and selectivity of their protections. There were problems with coordination and selectivity of some fans, which had fuses of 63 A, and according to the study done, they should be of 50 A.

However, when the fan was in use, the fuse broke, so the 63 A fuse has been maintained. In this case, a new study will be carried out to evaluate the use of the 50A fuse. The cables that are not suitable, for having a voltage drop above 2%, the best time to change them is being studied, but there is no estimate of when this change will take place. Thus, after the interventions were completed, 83% of the motors analyzed had the coordination and selectivity of their protections adjusted correctly.

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Appendix A - Data Table Motors, Fuses and Relays

TAG	FUNCTION	CV	Before					After				
			P	In	Installed Fuse	Thermic Adjust	Thermic Relay Range	P	In	Installed Fuse	Thermic Adjust	Thermic Relay Range
320B.4409	BB. BOOSTER HIGH PRESSURE CLEAN. FLOORS	30	2	35	80	36	32 - 50	2	35	50	36	32 - 50
320M.4008	BUILDING FAN BASEMENT MACHINE	20	6	29	63	29	20 - 32	6	29	50	29	20 - 32
320M.4009	BUILDING FAN BASEMENT MACHINE	20	6	29	63	20	20 - 32	6	29	63	29	20 - 32
320M.4012	BUILDING FAN	12.5	8	17.2	63	16	16 - 25	8	17.2	25	17,5	16 - 25
320M.4013	BUILDING FAN	12.5	8	19	50	18	16 - 25	8	19	25	19	16 - 25
320M.4014	BUILDING FAN	12.5	8	19	50	14	12.5 - 20	8	19	25	19	12.5 - 20
320M.4016	BUILDING FAN	7.5	8	11.6	50	16	16 - 25	8	11.6	32	11,6	16 - 25
320M.4017	BUILDING FAN	7.5	8	14	25	19	12 - 20	8	14	20	14	12 - 20
320M.4018	BUILDING FAN	7.5	8	14	25	14	10 - 16	8	14	20	14	10 - 16
320M.4030	BUILDING FAN	12,5	8	20	32	15	10 - 16	8	20	32	20	16 - 25
320M.4035	CUBIC ROOM FAN. 13.8 KV	3	8	5,5	10	6	4 - 6.3	8	5,5	20	6	4 - 6.3
320M.4036	FAN ELECTRICAL ROOMS BT. And MT.	7.5	8	14	25	15	10 - 16	8	14	25	14	10 - 16
320M.4050	BUILDING FAN	7.5	8	14	25	15	12.5 - 16	8	14	25	14	10 - 16
320M.4051	BUILDING FAN	7.5	8	14	25	14	10 - 16	8	14	25	14	10 - 16
320M.4052	BUILDING FAN	7.5	8	14	25	16	16 - 25	8	14	25	14	10 - 16
320M.4055	BUILDING FAN	7.5	8	14	25	14.2	10 - 16	8	14	25	14	10 - 16
322B.4411	BB. BOOSTER HIGH PRESSURE CLEAN. FLOORS	30	2	36.1	100	36	32 - 50	2	36.1	63	36,1	32 - 50
322B.4573	BB. LUBRICATION SYSTEM 30 GMP DRY PART	4	6	6,2	25	6.3	6.3 - 10	6	6,2	10	6,2	6 - 10
322B.4574	BB. LUBRICATION SYSTEM 30 GMP DRY PART	7.5	4	11	25	11	10 - 16	4	11	25	11	10 - 16
322B.4575	BB. WATER RECIRCUL. CHUV. OSCIL. HIGH PRESSURE	5	2	7.5	10	6.3	6.3 - 10	2	7.5	10	7,5	6.3 - 10
322B.4576	BB. WATER RECIRCUL. CHUV. OSCIL. HIGH PRESSURE	2	2	2.85	16	2.6	2.5 - 4	2	4	10	4	2,5 - 6,3
322B.4581	BB. CONDENSED TQ. CONDENSED	4	4	5,5	20	6.3	6.3 -10	4	5,5	10	5,5	2,5 - 6,3
322B.4583	BB. WATER VACUUM BOX OF FELT	5	4	6.9	20	7.5	6.3 - 10	4	6.9	20	7.5	6.3 - 10
322B.4591	BB. COOLING WATER VENT. CIRC. LU / LS	5	4	6.9	32	6.3	6.3 - 10	4	6.9	32	6.3	6.3 - 10
322M.4156 .2	VALVE SWITCH TRAPS SCREEN	0.5	4	1	6	1	1 - 1.6	4	1	6	1	1 - 1.6
322M.4158 .2	VALVE SWING SCRAPS PRESS	0.5	4	1	6	1.1	1 - 1.6	4	1	6	1	1 - 1.6
322M.4166 .2	OSCILLATION OF ROLLER SCRAPS	5	4	1	6	1	1 - 1.6	4	1	6	1	1 - 1.6
320M.4015	BUILDING FAN	12.5	8	17.2	32	18	10 - 16	8	17.2	32	17,2	10 - 16
322B.4408	BB. SODA	30	2	36	63	32	20 - 32	2	36	63	36	32 - 50

Continue………

322B.4554	BB. TQ. WHITE WATER FOR PULP	20	4	32.1	63	26	25 - 36	4	32.1	50	32,1	25 - 36
322B.4558	BB. CHUV. LUBRIF. ROLLING SCREENS AND SEALING CX. VACUUM	12.5	4	16.65	32	17	16 - 25	4	16.65	25	17	16 - 25
322B.4561	BB. OF THE SHOWER (PROVISIONAL POSITION 14.2)	30	2	25.6	80	40	32 - 50	2	25.6	32	26	25 - 36
322B.4562	BB. OF THE CHUV. LUBRIF. RASPAD. AND ROLLS OF FELT	10	4	13	32	14	10 - 16	4	13	25	13	10 - 16
322B.4569	BB. TQ. BBS. OF VACUUM	15	4	19	63	20	16 - 25	4	19	32	19	16 - 25
322B.4570	BB. OF HOT WATER	3	4	4.6	25	11	10 - 16	4	4.6	10	4,6	2,5 - 6,3
322B.4571	BB. OF THE LUBRICATION SYSTEM 30 GMP.	7.5	4	10	25	11	10 - 16	4	10	20	11	10 - 16
322B.4572	BB. OF THE LUBRICATION SYSTEM	7.5	4	10	20	7.5	6.3 - 10	4	10	20	11	10 - 16
322B.4582	BB. OF CONDENSED TQ. CONDENSED	5	4	7.5	32	19	16 - 25	4	7.5	16	7,5	6,3 - 10
322B.4596	CHILLING SHOWER PUMP	15	2	19	32	16	16 - 25	2	19	32	19	16 - 25
322M.4164.5	COLD AIR FAN (HEAT RECOVERY)	5	6	8	32	6.3	6.3 - 10	6	8	16	8	6.3 - 10
322M.4162.3	UNIT. HYDRAULIC ENHANCEMENT	10	4	13.3	32	13.8	10 - 16	4	13.3	20	13,5	10 - 16
322M.4163.4	OSCIL. SCRAP CLEANING YANKEE CYLINDER	0,5	4		10	1.7	1.6 - 2.5	4	1,5	6	1.7	1.6 - 2.5
322M.4163.8	ITEMS. HIDR. LUBR. RED. ACTION. YANKEE CYLINDER	3.5	6	5.8	20	5.8	4 - 6.3	6	5.8	16	5.8	4 - 6.3
322M.4163.9	ITEMS. HIDR. LUBR. RED. ACTION. YANKEE CYLINDER	3.5	6	5.8	20	4	4 - 6.3	6	5.8	16	5,8	4 - 6.3
322M.4166.3	TRANSFER ARM. WALL TAB	5,5	4	7,5	25	7.5	6.3 - 10	4	7,5	16	7.5	6.3 - 10
322M.4166.4	PRIMARY ROLLER ARM	5,5	4	7,5	32	8.5	6.3 - 10	4	7,5	16	7,5	6.3 - 10
322M.4166.5	SCREW CIRCULAR SAW	1,5	2		10	2.5	1.6 - 2.5	2	2,5	10	2.5	1.6 - 2.5
322M.4201	TQ SHAKER. Of starch	2	6	3,3	16	4	4 - 6.3	6	3,3	10	4	2,5 - 6,3
322M.4233	UNIT. WEIGHING SYSTEM HYDRAULIC	7,5	4	10	10	1.6	1 - 1.6	4	10	20	10	10 - 16
322M.4246	HYDRAULIC UNIT VAPOR BOX VIB	5	4	7	50	6.1	4 - 6.3	4	7	16	7	6,3 - 10
320M.4007	REFUGE TRANSPORTER	7,5	4		16	12.1	10 - 16	4	12	32	12	10 - 16
320M.4011	BUILDING FAN	12,5	8	16.7	32	32	32 - 40	8	16.7	32	17	16 - 25
320M.4023	FALSE CEILING FAN	15	6	21	50	16	16 - 25	6	21	50	21	16 - 25
321B.4407	BB. OF OIL OF UNID. HIDR. OF THE REFLEX PULP	0,5	6	1.3	36	1.45	1.6 - 2.5	6	1.3	6	1.45	0,4 - 2,5
321B.4453	BB. ITEMS. HIDR. SHORT FIBER PULP	1	4	1.5	6	1.6	1.6 - 2.5	4	1.5	6	1.6	1.6 - 2.5
321B.4463	BB. TQ. OF MIXTURE FOR SWEETNER (FL)	20	4	25.7	50	25	25 - 32	4	25.7	50	26	25 - 32
321B.4464	BB. TQ. MIXTURE (FL) P / TQ.	10	4	14.5	32	14.5	10 - 16	4	14.5	32	14.5	10 - 16
321B.4493	BB. OF THE 4ST CENTRIFUGAL PURIFICATION STAGE (FL)	10	4	13.5	32	14.5	10 - 16	4	13.5	32	14.5	10 - 16
321B.4499	BB. WATER NETWORK OF THE DEPUR.	7.5	4	10	20	13	12.5 - 20	4	10	20	13	12.5 - 20
321M.4061	TQ SHAKER. DE F.L.	25	4	32.4	63	32	32 - 50	4	32.4	63	33	32 - 50
321M.4072	TQ SHAKER. MACHINE (F.L.)	15	4	20	50	20	12.5 - 20	4	20	50	20	12.5 - 20
321M.4099.2	DISCHARGE FILTER OSCILLATING SHOWER	0,5	4	1.13	6	1.6	1.6 - 2.5	4	1.13	6	1,13	0,4 - 2,5
321M.4107	PRESSURIZED SECONDARY DEPURATOR	15	4	18.6	50	19	16 - 25	4	18.6	32	19	16 - 25

Continue………….

321M.4135	BB. OF TQ VACUUM. SEPAR. OF AIR OF DEPUR. CENTRIF.	6	4	8	20	8	6.3 - 10	4	8	20	8	6.3 - 10
320B.4401	BB. WATER COOLING SEAL	15	2	17,7	50	17	6 - 20	2	17,7	32	17	6 - 20
320B.4402	BB. COOLING WATER	15	2	18	50	18	16-25	2	18	32	18	16-25
321B.4466	BB. DO TQ. OF MIXTURE (F.C.) P / TQ. OF MACHINE (FL)	15	8	22	50	20	20-32	8	22	50	22	20 - 32
321B.4467	BB. OF THE FIBER SYSTEM RECOVERY SYSTEM	25	6	32	50	40	32-50	6	32	50	32	32-50
321B.4471	BB. OF THE FIBER SYSTEM RECOVERY SYSTEM	25	6	32	50	32	32-50	6	32	50	32	32-50
321B.4475	BB. DO TQ. DISSOLUTION (WS)	3	4	4,5	6	4	4-6,3	4	4,5	10	4	4-6,3
321B.4476	BB. DO TQ. OF RECOVERED PASTE	10	6	14,5	25	14,3	10-16	6	14,5	25	14,5	10-16
321B.4480	BB. DO TQ. OF CLEAR WATER FOR DILUTION (NCR)	30	4	38	80	39	32-50	4	38	63	39	32-50
321B.4484	BB. OF THE THIRD STAGE OF DEPUR. CENTRIF. (F.L.)	15	4	20	32	20	16-25	4	20	32	20	16-25
321B.4485	BB. OF THE SECOND STAGE OF DEPUR. CENTRIFUGAL (F.L.)	30	4	38	80	32	32-50	4	38	63	32	32-50
321B.4487	BB. OF THE THIRD STAGE OF DEPUR. CENTRIF. (F.C.)	15	4	20	50	20	16-25	4	20	50	20	16-25
321B.4488	BB. OF THE SECOND STAGE OF DEPUR. CENTRIFUGAL (F.C.)	30	4	38	100	60	50 - 63	4	38	100	60	50 - 63
321B.4495	BB. OF THE FOURTH CENTRIFUGAL DEPURATION STAGE (F.C.)	10	4	13,2	25	14	10-16	4	13,2	25	14	10-16
321M.4066	TQ SHAKER. SHORT FIBER	25	4	31,9	80	32	32-50	4	31,9	63	32	32-50
321M.4074	TQ SHAKER. OF MIXTURE (F.C.)	30	4	37	80	39	32-50	4	37	63	39	32-50
321M.4093	TQ SHAKER. OF RESINS (WS)	2	2	3,45	16	4	4-6,3	2	3,45	16	4	4-6,3
321M.4097	RECOVERED PASTE TQ SHAKER	20	4	26,7	63	28	20-32	4	26,7	50	28	20-32
321M.4104	BREAKDOWN TOWER SHAKER	25	4	32,4	80	32	32-50	4	32,4	63	32	32-50
321M.4105	VIBRATING SIEVE	4	8	6,8	16	7,8	6,3-10	8	6,8	16	7	6,3-10

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