CONTRACTS FOR THE SUPPLY OF ELECTRIC POWER FROM THE MANUFACTURER'S POINT OF VIEW.

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It is becoming daily more common for the manufacturer to cease operating his own power plant and to take a supply from an electric power company, under contract for a term of years.

The technical terms of such contracts are usually more fully thought out by the power company than by the manufacturer. The power company have a thorough grasp of the technical conditions and of the results to be expected from past experience in similar matters, which the manufacturer has not. The contract contains technical clauses, as distinct from legal clauses, which neither the manufacturer nor his legal adviser, however competent, can fully grasp in all their bearings. Any "snags" hidden in these technical clauses usually only come to light after the contract is signed, sealed and delivered and the accounts rendered.

Most contracts for any considerable amount of electric power now contain a clause that the "power factor" of the load must be kept within certain defined limits or an extra charge will be made, and there is probably no other one clause which, when enforced, has led to more misunderstanding and dissatisfaction.

The following are samples of these clauses:—

(1). "When the power factor of the greatest amount of power taken for said twenty minutes falls below 90%, the corporation shall pay for 90% of the said power divided by the power factor." (Hydro-Electric Commission of Ontario).

Here the reference to "twenty minutes" means that the charge will not be based on a peak load lasting less than 20 consecutive minutes at any one time.

To interpret the extra charge due to the power factor, suppose that a 100 h.p. is taken and that the power factor turns out to be only 80%.

Then 90% of 100 h.p. = 90 h.p. A power factor of 80% = 0.80. 90 h.p. divided by 0.80 = 112.5, so that the customer will have to pay for 112.5 h.p., or 12½% more.

(2). "The city..... agrees to pay for the energy on the basis of at least an average 90% power factor, and should the energy be found to be delivered at less than an average 90% power factor, the basis of payment shall be adjusted by increasing the payment calculated as above, so as to make it correspond to a delivery of power on a basis of 90% power factor."

If we take the phrase "make it correspond" to mean proportionately, then if the apparent power was 100 h.p. and the power factor proved to be 80%, the power to be paid for would be: $100 \text{ h.p.} \times \frac{90}{80} = 112.5 \text{ h.p.}$, as in the previous instance.

(3). "The intent of this contract is that the Cement Co. shall arrange its equipment so that the power factor shall be about 90% and that the measurement shall be so made that the Cement Co. shall pay for the true and not the apparent energy."

This is not very clearly expressed, but the intention is the same as in the previous instances.

To arrive at a clear understanding of this matter we should consider three points:—

(1). What is the "power factor" of a supply of electric power, and why does it affect the cost of power?

(2). What power factor can usually be obtained under ordinary conditions, and what will any variation amount to in dollars and cents?

(3). If the power factor is not as good as it should be, what can be done to improve it?

To really grasp the full meaning of the "power factor" of an electric supply necessitates acquaintance with the principles of alternating current, but it can be made fairly clear without this. Alternating current reverses its direction of flow so many times a second (standard practice is 25 or 60 complete cycles per second) that the result as regards power supply is equivalent to a steady flow in one direction. The main object of these reversals is to give facility for transformation from one voltage or pressure to another, thereby enabling the use of static or stationary transformers for altering the pressure, instead of moving machinery, and generally increasing the facility of transmission and distribution.

The current flows at a certain pressure or voltage, and so long as the waves or rushes of current and pressure are simultaneous, that is, "in phase," the power factor is said to be a 100%, or, as there is no effect due to it, we may consider that there is no power factor.

A supply to incandescent electric lamps only, gives a load factor so nearly 100% that the effect is not worth consideration.

The connecting of motors to a circuit, however, immediately introduces a power factor. The motors have an inherent property called self-induction, which amounts to a back pressure or voltage causing a part of the current to be out of phase with the pressure. The power delivered then consists in effect of two currents, one of which is in phase with the pressure and is doing useful work, and the other, which is known as "idle" current, doing no work except heating the conductors through which it passes. The "true electrical energy" is the product of the current and pressure which are in phase; the "apparent energy" is the sum of the two currents multiplied by the pressure and is what would be obtained from the readings of the ammeters and voltmeter.

The difference between this "true" and "apparent" energy constitutes the power factor, and the power factor of any circuit $= \frac{\text{true energy}}{\text{apparent energy}}$.

This "idle" current has to be reckoned with, however, on account of its heating effect, and if it exists and to the proportion to which it does exist, the power company has to increase the size of its generators, transformers and transmission lines in order to carry it, and thereby increase its capital expenditure proportionately.

The wattmeter, or instrument used to measure the power, records only the true energy, and the power company would not, therefore, be paid for the "idle" current, though it costs them money to produce it.

Since the idle current, or, say, the power factor, is caused by the customer's load, and since it is to a great extent within his control and not at all within control of the power company, it is but just that the customer should be required to keep it within reasonable limits.

A physical analogy, though not exact, may make the meaning of "power factor" clearer.

Suppose a manufacturer, without stating the conditions of delivery, contracted for the supply of a certain quantity of water per day. The supply through a given pipe in a certain time would depend upon the pressure. If, now, the delivery pipe entered at the **bottom** of a high tank which was kept full, then the head of water in the tank would cause a back pressure on the supply, which would mean increased work to the pump and, therefore, increased expense to the contractor, for which he would be justified in expecting increased payment. This back pressure corresponds with the power factor