DESIGN CRIMES IN ELECTRICITY DISTRIBUTION

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Introduction

For any business to remain competitive it must ensure that it obtains the maximum return on its investment and that the value of its product exceeds the price paid for it. This implies that the infrastructure that is developed by a business must be able to undertake the objective for which it was developed at the least cost. The cost must be the least cost over the life of the infrastructure including capital, operating, maintenance, support, safety and disposal. The majority of the costs are committed by the stage that the infrastructure is designed. As a result if all the consequences of the design have not been taken into account at this stage, the life costs will not be minimised and the return less than it could have been. In the case of an electrical utility, whose job is to transport electrical energy to the customer, capital utilised to develop the transport infrastructure, maintenability, operatability and failures contribute to the costs and should be minimised.

This presentation is a composite of slides that show some aspects that have contributed to extra costs to the business which should have been eliminated in the development of the infrastructure. The purpose of the slides is to sensitise the audience to some items that should be considered in the design stage to reduce costs. The slides are taken from the electrical utility environment but similar examples are evident in other businesses, often they have contributed in the bankrupting of the business. This is by no means a complete library of incorrect items on the system.

Slides

The slides that shown in the presentation illustrate examples of:
Problems due to poor layout planning,
Infrastructure not contributing to maximising investment return,
Wastage due to poor project management,
Failures due to poor design or implementation,
Failures due to incorrect voltage protection,
Failure due to low clearance,
Failures due to incorrect consideration of creepage,
Failures due to incorrect consideration of partial discharge,
Poor construction practices,
Poor maintenance practices,
Poor risk mitigation.

Planning

The first slide illustrates an example of a larger customer in an electrified area. This customer was placed at the end of a LV system resulting in low voltage at the supply terminals. A preliminary survey of the area prior to layout design would have resulted in a more optimal placing of the transformer. Supply- system losses increase with distance from the transformer and by having this power consuming customer at the end of the LV system both increased system losses as well as an unhappy customer. The second slide is an indication of a similar occurrence resulting from poor re-engineering as a system load increases.

The second series of slides illustrate where capital has been spent on infrastructure were it has not been necessary. In these cases more care in the design stage would have resulted in reduced capital expenditure for the same revenue. The extra capital is due to utilising extra service poles, oversized service cables, arbitrarily installing service boxes, building three phase lines where only one was needed and building longer lines than needed and using extra stays.

The third series of slides refers to the choice of structures. Guidelines show the correct choice of structures for specific situations. Choosing a structure designed for short spans for use in long spans will result in outages due to clashing, customer spikes, excessive maintenance costs and unhappy customers.

Construction

The fourth series of slides shows incorrect construction methods. These will again result in maintenance expense and in some cases create a safety hazard. Note that the creation of a safety hazard can result in a considerable expense to the business.

The fifth series show the result of poor construction practices. Should the jumpers around a strain pole be poorly placed there will end up a low BIL structure. In the case of poles being planted to an insufficient depth or poor backfilling the result is leaning / broken poles. Underground cables are a broblem should the construction practice not be carefully monitored. Cables that were to be placed with suitable spacing will be seriously de-rated should the spacing be compromised. In addition the poor laying methods will result in later cable failures. This is especially the case with rocks in trenches. Finally in project management there will be a tendency for wastage if proper controls are not in place. This will tend to increase the project cost for which there is no return.

Surge Protection

The sixth series of slides show how the positioning and connection of surge arresters will reduce the protection for equipment. An increased probability of failure will result from the incorrect positioning of surge arresters, in turn resulting in increased maintenance expenditure and a reduced quality of supply. What is often ignored in the placement of surge arresters is the volt drop along the surge arrester leads. This volt drop is in addition to the surge arrester voltage. The surge arrester/lead voltage should be kept to a minimum to maximise the protection level. This is especially relevant as the protected unit’s BIL reduces with age.

Creepage

Equipment on the system should be designed, taking account the creepage distances between any live terminal and ground, the air gap between any live terminal and ground and any air gap breakdown for a shrouded connection. Often one of these is compromised in the design of equipment. The problem is that generally the type tests that are specified will not pick up these deficiencies and the “latent defect” will only result in failure years later. The slides in this series show the results of these types of failure.

The seventh series of slides shows the effect of insufficient clearance and creepage within equipment. If there is insufficient clearance there will be a breakdown between the live part and ground or another phase. In the case of insufficient creepage tracking will begin along the insulation surface which will result in a flashover.

Breakdown

The eighth series of slides relate to the effects of breakdown around shrouded parts. The breakdown referred to is generally in the air surrounding the shrouding. The permaittivity of insulation material will determine the voltage ratios across different materials between two voltage points. When one of the materials is a solid dielectric and the other is air the greater voltage is invariably across the air. The air unfortunately will normally have the lower breakdown voltage. This will often result in breakdown of the air. This breakdown will generally cause the solid insulation to be gradually eroded and result in later equipment failure. The relationshoip between gap width and insulation thickness is illustrated for one case in the attached table.

Ds (mm)	Va (kV)	Va/mm
0	20.0	1.1
6	17.5	1.5
12	12.7	2.1
17	3.4	3.4
18	0	0

The slides illustrate the effects of this phenomenon in switchgear.

Safety of personnel is seriously compromised along with loss of supply and increased maintenance when a cable termination is not correctly made off or if a termination is utilised for connecting to a unit for which it was not intended. The slides indicate an incorrect termination utilised to connect to a switch along with the resultant hot spots being developed. Specification NRS 012 has been developed to give guidance as to the spacings to be utilised for a termination in air. Not complying with these termination clearances can result in dangerous breakdowns in the termination box.   Note that in a termination box arcs are contained which can result in an explosion.

Maintenance

The wrong things done during system restoration can also result in disaster. Protection is in place on a system to ensure that if a fault does develop then the rest of the system is not damaged. Should this protection not work or be shorted out, a minor fault can result in major consequences. The replacement of broken discs in an insulator string can also lead to unexpected failure due to the mismatch of the insulators. Flashover occurs across the clean insulators.

Weak points

Finally a point to think about in designing a system. Although the OHSAct and other codes specify the design criteria that should be utilised, the question should always be asked is what should fail if these limits are exceeded. Should there be a weak point designed to fail? Slides show the effects of failed towers and failed switchgear. Which has the best weak point?

Conclusion

For the system to operate to maximum productivity there needs to be a concerted effort to ensure that the consequences of all activities undertaken are considered. The slides shown in the presentation are a small sample of things that should be considered when running an electrical utility.