QUALITY ASSURANCE

One of the principal objects of inspection engineering is to assist in providing adequate assurance that the quality of product differs no more from the standard than should, from an economic viewpoint, be left to chance. This factor of assurance must be considered in writing inspection specifications, in handling complaints, in judging non-conformance cases, and in preparing the quality report. Hence inspection engineers are concerned with: 1) the nature of assurance, 2) the basis of assurance, and 3) the kinds of assurance to be rendered. The object of the present memorandum is to present certain principles basic to the act of providing quality assurance.

NATURE OF ASSURANCE

Principle 1 - Assurance from the viewpoint of the one having the assurance is a state of mind involving a belief in the happening of some future event.

In the case of quality, assurance is a state of belief about the nature of the quality of some thing expressible in the form, "If I carry out such and such operations on the thing in question, I believe (to some felt degree) that I shall experience such and such qualia or pointer readings". It is significant to note that the event in the case of quality is one depending partly upon the act of the one having the assurance. This state of believing is one experienceable through introspection; it is in a certain sense quantitative. The only method we have for measuring it, however, is a certain crude feeling as to the degree of assurance or belief in our own mind. Such feelings lie behind verbal expressions like: "This thing may have such and such qualities", "I think this thing has such and such qualities", "I am pretty sure that this thing has such and such qualities", "I am quite sure" and the like.

Principle 2 - Your assurance can be nothing more for my knowing than a certain construction which I put upon certain of your acts.

In other words, one cannot experience the feeling of assurance or belief of another; one can only experience how another acts. There is, however, a serious difficulty in trying to determine the belief of another by interpreting or placing

some construction upon his action. One's acts depend upon at least three factors: 1) the desire to attain a certain end, 2) the conceived method of attaining that end, and 3) the belief or assurance that the end may be attained through a given method. Given a certain end and a conceived method of reaching that end, the action one takes toward the end depends pretty much upon assurance alone. It is exceedingly difficult, however, to determine whether the controlling factor in the action of another is the wantableness of the end, the nature of the conceived method of attaining the end, or the degree of belief in the attainability of the end by the conceived method.

Principle 3 - Rational assurance is of the nature of a degree of belief p_b in some proposition P based upon given evidence E.

In order to get at an understanding of assurance we must consider both the end or object of assurance and the basis of assurance. In other words, in order for one to think meaningfully about his own state of assurance, he must have in mind definite answers to the questions: "Of what am I to be assured?" and "Upon what evidence am I to base this assurance?" In the case of quality assurance, the "of what" must be of the nature of propositions about certain experienceable qualia to be associated with certain operations on the thing in question, and the evidence must be some past experience. The failure to take into account these two aspects of assurance leads to much loose talk.

Principle 4 - Given any operationally definite meaning of the quality of a particular kind of thing, and given any definite evidence E about the quality of a thing, there exists an objectively definite degree of rational belief p_b' that the given thing has the quality meant.

This principle is the same as Principle 7 in *Q.M.* 4. It is one of the most important principles in guiding one's consideration of their own way of thinking about the matter of assurance. Strictly speaking, the validity of this principle can only be tested in respect to one's own first hand experience in attempting to act rationally. One seldom, if ever, finds that he is completely satisfied with the degree of assurance arrived at through analysis of his experience. In other words, one is always driven on and on, ever grasping for that ideal degree p_b' of assurance which he more or less tacitly assumes to be attainable through the process of thinking.

It is some such concept or principle which makes us interested in thinking in an effort to arrive at "knowledge" or "truth" for its own sake. This principle is pretty much a keystone in any life of reason and from this viewpoint belief in it is a dynamic driving force behind individual mental effort. It is important, how-

ever, in our consideration of the nature of assurance to note that when one is interested in giving assurance as we say, to another, or more properly, when one is interested in acting in a way that will influence another to become assured in a given case, one must have recourse to some principle fixing interpretation in terms of the reactions of the other person under specific conditions.

Principle 5 - There is no such thing as assurance in the abstract - there can only be the assurance of some person.

This follows as an important corollary of the previous principles. Hence we, as inspection engineers, in carrying out our responsibility of assisting in giving adequate assurance that the quality of product does not differ from standard more than an amount which should from an economic viewpoint be left to chance, must consider to whom this assurance is to be given. We cannot simply give assurance to the world in general.

If we, as inspection engineers, are to be called upon to give assurance to someone, it is but logical that we examine next the available means to that end; in other words, that we inquire into the basis of assurance.

THE BASIS OF ASSURANCE

Principle 6 - Any set of data has evidential value only within a framework of pre-existing experience both in the form of sensuous and emotive qualia and their interrelations and in the form of a priori concepts underlying the thought about these qualia and their interrelations.

In other words, any data bearing upon the quality of any single thing has assurance value only within a framework of preexisting experience. So far as the pre-existing framework differs for different people, so also will the evidential or assurance value of any given set of data differ for these people. Hence it is that evidence, like assurance, is pretty much a personal matter. It does not exist in the abstract.

Now, from the viewpoint of giving assurance or collecting data adequate to give assurance, it follows from this principle that we must try to take account of the prior conditioning of prior experience of the one to be assured, both in respect to the sensuous and emotive experience and the thinking experience. If two people are not conditioned the same in respect to these two factors, a given set of data cannot have the same significance to both. All that an inspection engineer apparently can do under such circumstances in order to give assurance to another (or at least to be in a place potentially to give such assurance) is to create (or to be able to create) in the mind of another the willingness to act in such a way

that when he has experienced the results of his own act he will rise up and call the inspection engineer blessed.

To clarify this point, let us consider the case of trying to get across to an engineer not conditioned to a statistical way of thinking the assurance which a complete statistical analysis of a given set of data by a competent engineer of broad statistical training yields to that engineer. The one who tries to do this with the idea of getting the other fellow to experience the assurance which he feels <u>because</u> of the results of the statistical analysis is doomed to failure. Granting for the moment that this statistical conditioning of the inspection engineer analyzing the data helps him in a given case to make a prediction which in the majority of times will turn out favorably, the only thing that the inspection engineer can hope to do is to get the other fellow to act in such a way that in a succession of trials he will satisfy himself that the prediction of the inspection engineer works. In this way the inspection engineer and the other fellow may come to have somewhat the same degree of assurance <u>but upon entirely different grounds</u>. To one, $\bar{X}$'s, σ's, control charts, and the like, may be an important part of the basis for assurance; to the other, these may be non-meaningful. In other words, the inspection engineer may create in the mind of another the same degree of assurance that he himself has, insofar as the assurance is the motive power behind an act, but he can seldom hope to create that assurance upon the basis of the same kind of reasoning that he himself uses. It is for this reason that inspection engineers will always be largely judged by how the other fellow likes the results of his acting upon the suggestion of the inspection engineer. If one could hand out evidence in buckelfuls like water, the inspection engineer's problem would be simple indeed. The trouble is that when the other fellow reaches for a bucketful of evidence upon which assurance is to be based, this very process changes, as it were, the evidential value of that for which he reaches.

To take a case outside the field of inspection engineering, let us consider a doctor treating his patient for some more or less complicated ailment. After a thorough and careful analysis of many different factors the doctor arrives at some conclusion, the nature of which he might, for example, be able to express rather easily to the patient, possibly in the form that the patient will recover. The doctor may by a certain line of argument stimulate the patient to the same degree of assurance that he himself has that the patient will get well but unless the patient is conditioned in medical thinking and experience, the doctor cannot give

his own basis for assurance. Much of what is evidence to the doctor would be non-intelligible to the patient. The only thing the doctor really can do is to get the patient to think that he is going to get well in the case in question and trust that his diagnosis is correct. The most painless method of creating the desired degree of assurance on the part of the patient is perhaps the best for all concerned.

In other words, this whole matter of giving assurance is pretty much the art of using the most painless method of getting the other fellow to act in the way that you personally think he would want to act if he knew what you know about the data. In doing this one may slip in one or both of two ways: not guessing the other fellow wants and making the wrong interpretation of the data.

Principle 7 - Two important characteristics of evidence basic to one's assurance are: 1) the weight of evidence and 2) the quantity of evidence.

Every set of data bearing upon the quality of a thing must be taken by someone. In the simplest case such a set of data may consist of tabulated pointer readings, representing measurements of velocities, weights, lengths, tensile strengths, resistances, and the like. Every scientist and engineer recognizes that his interpretation of such a set of numbers depends to a certain extent upon his past experience with the one who took the data. If the data are to be used as a basis for drawing conclusions of a certain type, the assurance depends to a certain extent upon what the one drawing the conclusion knows or feels that he knows about the one who took the measurements. For example, if the measurements were taken by an experienced man the assurance given by them would have greater weight than if they were taken by a novice, even though numerically they might be the same in the two cases.

In any such case, however, the degree of assurance given depends also to a certain extent upon the quantity of data. For example, if the data represent repetitions of the same kind of measurement, the degree of assurance given by them varies in some way or other with the number N of observations.

In the case of weight of evidence, we have no very definite way of comparing sets of data except by the introspective feeling of someone, and quite naturally this method of comparison may not yield the same results for different people. On the other hand, assurance is generally considered to increase as the square root of the number of repetitive observations. The contribution to assurance provided

by weight is, however, not commensurable with that given by increasing the number of observations.

THE KINDS OF ASSURANCE TO BE RENDERED

Having considered the nature and basis of assurance, it is fitting that we now consider the kinds of assurance to be rendered by inspection engineers. Since, as already noted, assurance is something that cannot exist in the abstract, the kinds of assurance will depend upon the persons to be assured. Two important classes in quality engineering work are obviously the consumer and the producer. Hence two important kinds of assurance to be given are producer assurance and consumer assurance. Now, these two kinds differ not only in that they belong to different parties but also in respect to: How much assurance is wanted? Of what is assurance wanted? Upon what evidence is assurance to be based? In other words, if we consider assurance upon the basis of the classification as to who is to be assured, there are three bases for subclassification of the kinds of assurance, making a four-fold basis for classification:

Who is to be assured?	How much assurance is wanted?	Of what is assurance wanted?	Upon what evidence is assurance to be based?

In respect to who is to be assured, obviously there are important differences between consumers as a class as well as between producers as a class. Since it is not feasible to consider each and every one separately, some <u>average</u> must be struck for each of the classes. One of the fundamental rôles of the inspection engineer is to arrive at such acceptable averages.

In respect to "how much" and "of what", wide differences may be expected to exist between members of either of the two classes and broad general differences to exist between the two classes. In general, such discrepancies will, however, tend to diminish with a broader understanding of the fundamental problem of giving quality assurance. The problem of creating such a broader understanding distinctly belongs to the field of inspection engineering.

Now we come to the basis of quality assurance. Insofar as this rests upon pointer readings (or measurements if you please) the potential basis of assurance must be the same to all members of both groups, at least in respect to the measurements taken on any single piece of product. The very important thing, however, from the viewpoint of inspection engineering is that, in accord with previous

principles, these pointer readings can only be interpreted in terms of a framework of previously attained pointer readings of one kind or another. In other words, the potentially basic evidence depends not alone upon data taken upon a specific thing but also upon things of the same kind as well as certain other kinds of scientific measurements. An important function of inspection engineering is therefore that of keeping up to date the potentially basic evidence upon which assurance of either of the two major kinds may be rationally based.

We have seen, however, that interpretation of a set of measurements depends not only upon the framework of prior experience in respect to measurements but also upon the prior framework of rational thinking and the analysis of the data. It is therefore an essential part of any program of rendering either of the two major kinds of assurance that there be a department such as the inspection engineering department, charged with the responsibility of keeping up to date, not only in respect to the potential basis of giving rational assurance in terms of pointer readings but also in respect to developments in the logic of probable inference, or, in other words, developments in the scientific method of interpreting data of a statistical nature.

In other words, if we are to assume a rational approach to engineering problems, if we are to believe in the existence of objective scientific method, it is necessary to have some department charged with the responsibility of keeping abreast of developments in this particular field.[1]

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1. Engineering is not the only field in which such a necessity is experienced. It is basically the same kind of need that underlies the acceptance of judicial bodies in every civilized group, bodies charged with the responsibility of establishing rules of evidence and of rendering judgments upon the basis of such evidence as they choose to gather.