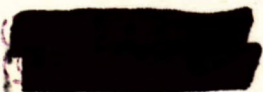


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O T T A W A October 21st, 1943.



R E P O R T
of the
ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1518.

Recommended Applications of Quality Control Principles
to the Inspection of Small Arms Ammunition.

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Origin and Purpose of Investigation:

The survey of inspection practice on the 20-mm. ammunition, requested in July, 1943, by the Director of Inspection Small Arms and Small Arm Ammunition, Inspection Board of United Kingdom and Canada, Ottawa, Ontario, has been completed. The Director wished to know how quality control principles could be applied to the inspection of this and similar products. Two prior reports have been submitted in the interim, containing information on Statistical Quality Control and a survey of conditions at the Dominion Arsenal, Quebec, Quebec.*

A study of the situation confronting the Small Arms inspectors has resulted in the following conclusions:

1. The major problem is to determine quality with sufficient accuracy, at a minimum expenditure of man-hours of labour.
2. The Small Arms inspectors are also interested in seeing that a constant level of quality is maintained.
3. The Small Arms inspectors are concerned with improvement of the quality of the product.

Quality control represents a new technique for managing industrial processes and evaluating the quality of

* "The Application of Quality Control to the Inspection of 20 mm. Hispano-Suiza Ammunition" --

(Origin and Purpose of Investigation, cont'd) -

the resultant product. The general philosophy of this science has been discussed with members of the Small Arms quality control inspection group. The specific recommendations which follow have been prepared with a view to assisting in the attainment of the three aims of the inspection department, i.e., determine quality, maintain quality, and improve quality.

Recommendations:

1. At each inspection point there should be one or more persons having had enough instruction on statistical quality control procedure to be able to (1) prepare fraction defective charts, (2) prepare average and range charts, (3) use double sampling tables.

This means that a person who is familiar with quality control will be at the point of operation, and having had this instruction he will be able to see opportunities for applying quality control ideas.

2. In applying quality control, one measurement should be studied and the procedure worked out thoroughly before any other measurements are undertaken.

The application of quality control should begin gradually. Existing measurements should, if possible, be used for the first application. Measurements which are readily available are: cap in cartridge case, velocity of shell, depth of chamber of the 20-mm. shell, weight of .303 tracer, and others.

(Recommendations, cont'd) -

3. Where 100 per cent of the product is inspected and a considerable number of rejects are found, a record of per cent rejects should be kept.

This record, kept in quality control chart form, gives a picture of fluctuations in the process. The process should be watched, because the danger of accepting defects increases with the amount of defectives manufactured. The cost of the product also increases as defects increase.

4. Where 100 per cent of the product is inspected and no rejects are found, reduced inspection should be considered after evidence of control has been obtained by dimensional inspection or tighter gauging.

When no rejects are found on the gauging of the dimension, there is no information as to whether the dimension is shifting nearer one of the limits or whether it is constant at the centre of the range. There is no knowledge about the variation of the product. In order to obtain more information it is recommended that, if possible, groups of articles should be collected and dimensional measurements taken. From the dimensional inspection a picture of the variation in the property can be obtained and from that decisions can be made as to whether or not reduced inspection is permissible.

If it is not convenient to take dimensional measurements, another way of obtaining information on the property is to use tighter gauges. Suppose that a dimension is required to be within $\pm .002$ inch. If gauges are made for $\pm .001$ inch a certain percentage would be expected to fall outside of these tighter gauges. By plotting the percentage outside gauge a

(Recommendations, cont'd) -

picture of variation in the product can be obtained and from this evidence decisions can be made as to whether or not reduced inspection is permissible.

If the dimension is a very important one it is all the more necessary to obtain as much information as possible about its variation, because although reduced inspection may not be desirable control over the dimension is definitely desirable, and by studying variation in the dimension its control may eventually be attained.

5. Where a certain per cent defective is permitted in lots of ammunition or of component parts, double sampling tables are available with which to select the most economical size of sample.

Table I shows a sampling table for the inspection of lots of 50,000 articles.

TABLE I.

<u>Average outgoing quality level, per cent</u>	<u>First sample</u>	<u>Number of defects allowed</u>	<u>Second sample</u>	<u>Total number of defects allowed</u>
0.1	2230	2	4650	12
0.25	1850	5	3500	21
0.50	925	5	2085	24
0.75	800	7	1640	29
1.0	610	7	1410	32
1.5	510	9	1130	38
2.0	480	11	1090	46
2.5	415	11	1145	54
3.0	390	13	940	56
4.0	295	13	725	57
5.0	230	13	605	59
7.0	180	14	460	63
10.0	140	16	355	69

Note that if the average outgoing quality level is required to be 1 per cent and the average defectives for the process is unknown, then it is required that a sample of 610 must contain less than 7 defectives. If more than 7 defectives are found, then a second sample of 1410 is drawn and the total number of defectives in both samples must not exceed 32.

(Continued on next page)

(Recommendations, cont'd) -

If the past record of the product is available, the size of the sample may be further reduced as shown in Table II.

TABLE II.

Reduced Inspection Based on Past History of Product.

Example. - Suppose the product must be maintained at an average outgoing quality level of 1.0 per cent defective. Lot size = 50,000.

<u>Past record of average per cent defective</u>	<u>First sample</u>	<u>Defects allowed</u>	<u>Second sample</u>	<u>Total defects allowed</u>
0 - 0.02	75	0	80	2
0.03 - 0.20	80	0	135	3
0.21 - 0.40	95	0	300	6
0.41 - 0.60	250	2	490	11
0.61 - 0.80	340	3	910	19
0.81 - 1.00	610	7	1410	32

Note that if the past record of fraction defective was 0 and the average outgoing quality level required were 1 per cent defective, then the first sample would consist of 75 pieces and the second sample of 80 pieces. This sampling technique is used by U.S. Ordnance and has been adopted as standard procedure wherever a certain fraction defective is permissible.

Where defects vary greatly in their seriousness, the indexing principle can be used.

Serious defects, multiply by 10,) or any number arrived
medium " " " 5,) at by those familiar
unimportant" " " 1,) with the product.

The total figure for defects can be used in double sampling tables.

6. Where measurements are in the form of variables, the possibility of reduced inspection should be investigated.

Some dimensions are obtained on dial indicators. If the readings so obtained are recorded and plotted in quality control chart form, it will be immediately evident whether or not reduced inspection is feasible. If there are indications that the product is under statistical control, then the per cent

(Recommendations, cont'd) -

inspected can be progressively reduced, step by step, as follows: 100%, 50%, 25%, 10%, 5%, 2%, etc. The time interval which must elapse between each reduction is about two weeks. Should any indication of lack of statistical control be found, inspection must immediately revert to 100 per cent and the reduction process starts over again.

7. Destructive tests should be plotted on quality control charts by the quality control chart method.

Very small samples are used to determine the velocity, accuracy, and explosive pressure of ammunition. The question which is often raised is, Do the 10 shots fired for velocity represent the 50,000 from which they were drawn? If indication of statistical control is evident in the firing results, we can then be fairly certain that the sample is representative of the material. If the results of firing trials do not indicate statistical quality control, then we cannot be certain that untested ammunition is similar to tested ammunition. It is recommended, therefore, that quality control records be made of firing tests.

8. The quality index of a product should be prepared WEEKLY or MONTHLY.

The management of industries often wish to have quality or cost of their product recorded as a single figure. In arriving at the index of quality the various types of defects are given weights according to their seriousness and the per cent defective times their weight factor are added, to give one value which is an index of the quality of that particular product over a certain period of time. This type of record would be useful to heads of

(Recommendations, cont'd) -

inspection groups, for visualizing operations at various points.

9. Inspection should determine quality level with a minimum of work, and return defective lots for re-inspection. This provides an incentive for the manufacturer to improve quality.

Example: In York Arsenal (Toronto), where per cent defect on 20-mm. shell bodies is usually over 2 per cent, inspection would examine 720 out of each 50,000. If more than 21 defectives were found, the whole lot would be returned to the manufacturer.

Example: At Dominion Arsenal (Quebec), where per cent defect on 20-mm. cartridge cases is over 0.3 per cent half of the time, 2,000 out of each lot should be inspected. If over 8 defects are found, return to manufacturer.

This method of preliminary inspection and rejection would give the manufacturer more work on lots with above-average per cent defective. The manufacturer would then have an incentive to reduce the number of defects in his product.

The manufacturer should be forced to screen out defectives to an acceptable level prior to examination of the product by Small Arms inspectors.

Summary:

Progress to date may be summed up as:

- (1) Arriving at a common understanding of the nature of Quality Control,
 - (2) Determining the inspection problems confronting Small Arms inspectors, and
 - (3) Putting forth recommendations as to where Quality Control may be used to advantage.
-

FUTURE ACTION:

Since Quality Control is a method of obtaining information, no statements can be made about what it will accomplish until some information has been collected.

It is recommended, therefore, that quality control records be made of various properties as mentioned in the body of this report.

The Committee, after looking over this information, may then draw conclusions and plan FUTURE ACTION.

Example: At Dominion Arsenal (Quebec), where per cent defect on 20-mm cases is over 0.3 per cent, 1000 out of each lot should be inspected. If over 0 defects are found, return to manufacturer.

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This method of preliminary inspection and re-jection would give the manufacturer more work on lots with above-average per cent defective. The manufacturer would then have an incentive to reduce the number of defects in his product. The manufacturer should be forced to return lots defective to an acceptable level prior to examination of the product by Small Arms inspectors.

(1) Arriving at a common understanding of the nature of Quality Control.

(2) Determining the inspection problems confronting Small Arms inspectors, and

(3) Putting forth recommendations as to where Quality Control may be used to advantage.

A D D E N D U M

Q U A L I T Y C O N T R O L C O M M I T T E E

A meeting was held in D. D.S.A.A.'s office on Tuesday, October 26, 1943, at 2:00 P.M., to discuss the Report of the Ore Dressing and Metallurgical Laboratories (Investigation No. 1518). The following attended the meeting:

- Wing Commander J. L. Burgess,
- Lt. Col. F. W. Huggins,
- Captain M. J. Ward,
- Captain J. P. Weston,
- Captain W. E. Sheldon,
- Captain A. J. Dubois,
- Mr. S. L. Burns, and
- Mr. H. H. Fairfield.

The Committee agreed to Recommendation No. 1 as a long-term policy. The training of suitable staff would be arrived at gradually from experience gained carrying out later recommendations.

The Committee agreed to Recommendation No. 2, modified as below:-

"In applying quality control, one item should be studied and the procedure worked out thoroughly before any other items are studied."

The Committee agreed to Recommendation No. 3, and added that the record percentage of rejects which can be taken from Form I.G. 150 (Defective Work Report) should be kept in quality control chart form.

The Committee agreed to Recommendation No. 4, modified as below:-

"Where 100 per cent of the product is inspected for non-critical defects and no rejects are found, reduced inspection should be considered after evidence of control has been obtained by dimensional inspection or tighter gauging."

The Committee agreed to Recommendation No. 5, modified as below:-

"Where a certain per cent defective is permitted in lots of ammunition or of component parts, double sampling tables should be used with which to select the most economical size of sample."

The Committee agreed to Recommendation No. 6.

The Committee agreed to study Recommendation No. 7. Captain Weston will collect information and will prepare Quality Control Chart for .305 Mk VIIz velocity and accuracy Proof Results. The information will be submitted to Mr. Fairfield before the next meeting. The information will be collected working backwards for 50 Lots from current production.

The Committee agreed to Recommendation No. 8 as, and when, Quality Control is put into effect.

The Committee agreed to Recommendation No. 9 being put into effect in cases where the Specification states that the Lot may be returned to the Contractor at the discretion of the Inspecting Officer, on a basis of percentage examination. This would tend to improve the general quality of work submitted for inspection.

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It was decided that I.S.A.A. (B) should install, at York Arsenals, a Quality Control Inspection to run parallel to the regular inspection, in order to compare results of the two systems.

It was decided at the meeting that Captain Dubois should install a parallel system to the inspection of the 20 m.m. cartridge case depth of anvil.

It was decided that Captain Sheldon should make a study of the application of Quality Control to the inspection of .303 Mk. VIIz.

Ottawa, Canada.
October 28, 1943.
HHF:MMD.