RESTRICTED

INSPECTION GAGES

4 March 1948

148-102

CONTENTS

	Page
SPEAKER--Mr. Clifford W. Kennedy, Quality Control Engineer, Federal Products Corporation, Providence 1, Rhode Island	1
GENERAL DISCUSSION	15

Publication No. 148-103
THE INDUSTRIAL COLLEGE OF THE ARMED FORCES
Washington, D. C.

RESTRICTED

INSPECTION GAGES

4 March 1948

COLONEL GODARD: Gentlemen, we in this College get, I would say, 98 percent high-level, very theoretical lectures. The people that we get from, say, the pick and shovel level, if you like that term, are few in number. But in the final analysis they are the people that have to do the work. When we plan for producing goods, we need our men on the pick and shovel level.

With that thought in mind we have brought in a man--and I mean no disrespect in using the term--from the pick and shovel level. He spent the entire war with the Remington Arms Company as chief inspector of their Denver Ordnance Plant. Prior to that he was in engineering in various phases, and has spent his entire life in shops. He will bring you the practical, down-to-earth approach to the problems of producing munitions of war.

His subject, "Inspection Gages," is, I think, probably one of the most important subjects we can consider, because everything made has to be measured in some way or another. Whether you use a ruler, a gage, or whatever it may be, you have to measure everything you make. From that point of view I am very much pleased to introduce Mr. Clifford W. Kennedy. Mr. Kennedy.

MR. KENNEDY: Gentlemen, I am, in the first place, going to be very informal in this talk. Secondly, I am going to be a little bit elementary. Colonel Godard did not mention my company. I wish you would consider me as representing the gage industry and not for the minute my own outfit. If during the course of the talk I unconsciously bring into it some commercial plugs, just overlook them. I have products of our competitors here as well as our own and will talk about them also. I will try to play fair. Then during the questions or discussion later just think of me as representing the entire industry. I am not up here advertising a single product.

I have sort of divided this up, with your permission, into two or three headings. I might tell you ahead of time that I would like to get in a few words as a line of thinking which should be useful when or if you have to attack a gaging problem sometime in the future.

As an example I might tell you ahead of time that in any shop you go into you come up against gaging problems. They always think all this stuff is all right, but they have special problems. When you boil it down, there is a common denominator for everything, certain basic conditions. Everybody thinks his particular problem is special, that they differ from the other fellow's problems.

There are many jobs where it pays to take the inspector right off the job and put it up to the operators and let them work their way out. We get so we lean on the inspectors. Lots of times my feeling is that we should take the inspector right out and see what happens, instead of to keep adding and adding inspection.

But look at it this way: Why inspect and gage? The first reason proposed is "comparing product with specifications." That is the whole reason in general for gages or inspectors.

And then as sort of a subheading we have gages and gaging because we want to make interchangeable parts. Perhaps the best military example I can think of at the minute is that during the late war we made cartridges at one plant and rifles at another plant. The cartridges made in one plant chambered in a chamber made in the rifle company's plant. Gaging is important when you want interchangeability of parts. We made things in one part of the world that fit things made in another part of the world. Gages played an important part in that.

Commercially gaging is used to reduce assembly cost and to procure better repair parts. From the commercial angle that is very important. You make up something and send it into the field. Something wears and they have to buy a part. Gaging plays an important part there.

From the point of view of management, without suitable gaging equipment of that nature, and without suitable inspection, you cannot and probably will not reduce scrap, salvage, and rework. Let us keep in mind when analyzing a manufacturer's production that it is not the total production that counts; it is the total net production that you can use. I was describing a plant this morning of which 26 percent of its production went into the ash barrel. Now, if you are planning on a hundred thousand units a month for that plant and a quarter of its production is no good, there is a problem of logistics there, isn't there? Gaging comes in there.

Important too, gaging down the line assures final product quality. A lot of people lose sight of that. It speeds up production. Incidentally, our friends in these collective bargaining agencies, the unions and things of that nature, are realizing more and more the importance of gaging and proper gaging equipment, because with it the operator can gain production and therefore can put more money in his pay envelope. They are beginning to look at that side of it. And that takes in the last item here, and that is that it makes the work physically easier for the operator.

So you can answer the question, "Is an inspection or gaging needed at this point?" and then go on to the next one. "Can operator gage, inspect and control quality or must there be an inspector in addition?" Here I am going to speak dogmatically. When you select gaging equipment or have anything to do with it, think of the operator. Never mind the blooming inspector. Never mind anything else. Get into the hands of the operator the

Now, to tell the operator two days later that he had made a bunch of scrap doesn't mean anything. It is not worth a cent. They were having trouble, of course, because, if you are making bad work, I don't care how many inspections you may put on it, it will creep through and get to your customer. You can't sort it out one hundred percent by gages or gaging to save your neck if you make it in the first place. You may get most of it, but not all of it.

They were having trouble. What did they do? We tried to solve the problem in several ways. One part of the solution was this: We set up between the management and the time department an arrangement whereby the operator was allowed time to make one piece with a micrometer which in his opinion was just the size that it should be. He was allowed the use of this special gage down the line. He was allowed to go down there and check it. That became his master. Then we supplied him with a little (indicating) gage like this, and he set that gage on that master. Then as he ground, he used his gage with his master. We put the whole job up to the operator, the responsibility and all, spent just that much money on gages, and cut out all that stuff down the line.

"Is gaging equipment expected to pay for itself, or must it be used anyway irrespective of immediate savings?" You have an example in thread gaging. If the threads are not accurate, the thing is no good. Lots of times, whether the gaging seems to mean anything or not, you must have control.

"Are components to be gaged again at some succeeding batch or final inspection, by customer or government inspector?" Well, the choice of situation affects the choice of gages. Suppose the government inspector is equipped with a snap gage for measuring a certain diameter of a part and the operator has one. Suppose the two gages are not alike, and one gage will reject parts that the other one won't. Things like that are always happening.

In a situation like that be sure that the government inspector, the fellow at the end, has the largest of the two gages. One of our favorite tricks was to take a worn gage away from the operator and put it in the hands of the inspector and to give the operator a brand new gage which was right down to size. Keep your tightest and smallest gages down near the source of the job, and don't reverse that situation. I am giving you only short examples of what happens.

"What class of help will use the gage--operator, inspector, supervision; high pay, low pay; high I. Q., moron, blind, crippled; male, female?" I remember a felt mill that I visited where they had a gage for measuring the thickness of the felt. They had an inspector running all around the room to these machines measuring this felt. Instead of giving him something like a micrometer or something he could carry in one hand, a little easy gage like this, they gave him one like this (indicating) He had to carry it

It is worn with the first stroke it makes. It is unreliable after the first measurement, to some degree. Insist on having at least a chrome-plated gage. It is better to have a Carbide or Norbide gage, which is capable of one hundred thousand measurements without any wear. It costs a little more than an ordinary steel gage; but if you want accuracy, if you want to know where you stand, want to know what the fellow is doing, give him the stuff to work with.

Of course, stuff like this Norbide will shatter if it is dropped. I remember in Denver, when the first glass gages came in, we went out and said to these fellows, "These gages are made of glass; so be careful. Don't drop them." Glass was very hard to get during the war. I went out there the next day and to my surprise the fellows in the shop that were using these glass gages were trying to be careful of them. The average fellow just reams a hole with the gage. So it is just a little trick.

I am not knocking mikes, because we manufacture them. But let us take a screw machine, plugging out parts at so many a minute. If the operator is normal, he is under a little bit of tension. He picks up a piece. He has a mike and he slips one of these pieces in here. We will say that he has to check four dimensions. He gets the first one. He must clamp it on and read it like this. If he is an old man like I am, he has a job. Then he has to get the next dimension. He has to clamp that mike on it like this. Then he has to read it again. He probably rolls that mike on his sleeve or his arm and gets it full of hair, which doesn't help it any. But he gets it on this diameter here. He checks it there and so on. Now, all this time the machine is plugging out the work and he is nervous. The biggest muscle in the body is the one that goes from behind the knee up to the back. So he stands working on that biggest muscle; and that being the biggest muscle, itgets the most tired.

Now, suppose you gave that operator a gage like this. They all know how to read a clock. You don't have to have bifocals to do that. Here is first dimension, here is his second, and here is the third dimension. You just do like this and read all four dimensions, just that quick. If you want to gain quality, think what you are doing when you buy gages.

And so we go. "Nature of supervision and the atmosphere in which the gage is to be used." We sent a gage out to a General Electric plant in the Midwest. It was a peach of a job. It was developed back east here. We went out a little while later and looked at it. It was under the bench covered with dust. The reason was that the gage showed up how poor the work had been. You run into that. You run into situations where they were not properly instructed in using the gage and the whole purpose is defeated. So lots of time you not only have a gaging problem, but you have to be sure that you carry on a training program as well.

Next on the list you have "radius, fillet, profile and template gages; squares." They are special gages for special shapes. They are still good for about a sixty-fourth.

Next you have the sine bar, V block, and other surface plate equipment. That is when you have to measure closer than a thousandth. If there is a gage man in the room, he is going to be right on my neck. He is going to say, "You can get closer than a thousandth without those." All I say is, "Watch out. Maybe you can, but maybe the man who is on the job can't."

Micrometers are very common and most useful tools. Somebody discovered that you can cut a screw thread, which is the basis of the micrometer, to hold the accuracy to about two-tenths of a thousandth. And that is true. That is one of the things that make a micrometer so good. But if you run up against a job where your tolerances are less than two or three-tenths of a thousandth, get away from your micrometer.

If I picked up this piece here and this set of micrometers and passed them out around you and had each of you measure that piece, I would get at a minimum fifty different dimentions. I would probably get a hundred different ones, but fifty at a minimum. There are not three of you out of the hundred and fifty who are here who can measure this piece alike with an ordinary micrometer under ordinary conditions.

So just watch that in the shop. Go for other equipment. Here I have to throw in a commercial plug because we happen to be the only ones in America now making this. If you want a micrometer and you want it closer than two-tenths of a thousandth accuracy, get an indicating micrometer and you will get what you want. I would have given my shirt during the war if I had had this type of equipment for measuring bullet diameters, because bullets have soft metal sleeves on the outside and the fellows on the line could give me any dimension they wanted with an ordinary pair of micrometers within three thousandths of an inch. They either clamp up too tight or they don't clamp up tight enough. They could give you almost any dimension they wanted to. If we had had equipment like this, we would have been spared a lot of trouble.

In between the steel rule and the micrometer there is what they call vernier equipment, illustrated mostly by this caliper. You may actually have a steel rule, but then you have a little specially designed scale in there with which you are able to read thousandths of an inch. You can't go any closer on vernier equipment. It is very handy and very useful, but watch when you try to use it on precision work.

The next thing perhaps is indicating equipment. You can get calipers with an indicator on them. You can read down to five or ten thousandths of an inch with indicating calipers. The average indicator is good for a tenth of a thousandth. If your work is any closer than that, cut out your mechanical indicator.

In electronics gaging you have a radio circuit. In here you have tubes and various things that a radio has. When you measure a piece on an electronic gage, you set up a power impulse. That power impulse may just make a hand move or it may flash lights; but because you set up a power impulse and because you have relays and tubes, you can take from that point and do anything you want with it. You can set up a system where that power impulse will stop the machine or where it will start it.

Another advantage of the electric and electronic gages is their sensitivity. When you are getting right down to a tenth or a hundred thousandth of an inch or a millionth of an inch--and there are production problems that require that--this is the general sort of equipment that you need to go into.

In the first place, you can set the equipment electronically. I don't know whether you can see that little hand in there or not. I move my hand and instantly change the balance on the lights. You don't have to set your equipment all the way by a manual adjustment. That is how delicate the thing can be. It can be set to measure over several scales. I will try to measure a millionth. Anybody who is sitting down front can see the pointer. You see that I am changing the reading about a ten-millionth just by the heat of my hand. If you are going to get closer than a millionth of an inch, you get an electronic microscope. This is the nearest to it. For your general type of extra precision work this is the thing.

Now on one other phase, on the mechanics of gaging, I would like to speak of the use of air. I am going to be very elementary.

If you change the direction of air, you change the pressure. The mere fact that a propeller revolves in the air changes somewhat the direction of the air and changes somewhat the pressure. In fact, it creates sort of a vacuum and that pulls the plane along. The mere fact that the wings move along against the air changes the compression and creates some vacuum, and the first thing you know your plane is going up in the air. We make use of that principle for gaging, for measuring.

In the first place, we produce air under a certain velocity. That is what this little compressor is doing. We have that air blowing out some little jets. This little plug here has two little jets. If we stop the flow of air, you see that column go down. If we stop it entirely, that is the ultimate. Now, somewhere between free flow and actual stoppage we can measure. So we restrict the air somewhat by setting it in a certain sized hole. The direction of the air is changed, and the pressure, and you get a reading on the gage.

Suppose that your piece has about a three-tenths variation in bore. I want to lecture--and I really mean, lecture--you for a minute on one of the toughest things to control in manufacturing, in metal cutting, and that

Then there was an extra sheet in the bunch given out here that has four pictures on it. The illustrations are not too good, but they have to do with fully automatic gaging. I can tell you that the one in the upper left-hand corner was designed for the Easterbrook pen people. They are making thousands of pen barrels all the time, and this thing sorts them out into over-size, under-size, and correct. There are three drawers there. They simply feed the things into the hopper and the machine grinds them out. They have something they can do with their over-size ones, and their under-size ones on to scrap. The rest they can send on to assembly. That is one way of getting out of trouble.

The other machine, shown in the upper right-hand corner and in detail in the lower left-hand, has to do with wrist pins. In that machine the wrist pins are fed through automatically. It measures the intrinsic diameter and classifies them six ways if you want it to, by selective assembly. It also tests each piece to see if it checks out of round. In other words, the pieces that this machine lets by are perfect for assembly with a cylinder and the connecting rod. That is all done in that machine.

The picture in the lower right happens to be the only picture I had on that. That shows the experimental work done with the Norton Company, the start of the experimental work, whereby a gaging head, an electric head, was put on the machine. We have an arrangement here in grinding whereby just a girl presses a button. A crank comes to the machine automatically. The girl guides it into place and clamps certain things. She presses another button and the machine starts. When that crankshaft is ground to within a hundred-thousandth of an inch of the correct diameter, the little gage mechanism stops the machine, the wheel is retracted, the crank is shoved back out of the machine, the girl presses a button, and it is automatically taken on to the next machine. Then she starts the cycle again. That is the part that gages play in automatic manufacturing.

Now, from the point of view of, shall we say, management, from the point of view of one or two things that you may get into sometime in the field either direct or, shall we say, in the form of consulting, if you have to give advice or offer suggestions, don't forget what I hinted about earlier. Insist throughout your career with gages that whatever you buy shall pay for itself. There is no use in even putting a pair of mikes on the job if you don't get improvement. I would like to emphasize that.

Now, another one. From time to time, in fact, regularly, we run into a situation--and you will--where a new product is being devised or a revision of a present product, and the engineers are all busy. The thing has been designed. In come the tooling engineers and they say, "We will work with a Van Norman or a Cincinnati or a Norton." In other words, they dope out the equipment, they dope out the tooling and things of that nature. In comes the methods engineer and he says, "We are going to have parts coming over here and going over there" and all that sort of stuff. They

COLONEL GODARD: I am sure all of you have gotten a much better appreciation of what gaging is and what it does from Mr. Kennedy's talk. We will take a few questions.

QUESTION: What effect does the air temperature and the temperature of the metal have on gages?

MR. KENNEDY: Ten inches of metal will expand a thousandth of an inch per ten degrees. I think that is right. Put it another way. If you have a gage like this, it is sensitive to a tenth of a thousandth. You keep your hand on it and keep transmitting temperature into it, it doesn't take but a few minutes to increase the temperature of the gage ten degrees from hand pressure. If the gage is of such size, you may throw your reading off anywhere from a tenth to a thousandth. I like to think of a ready rule of thumb for the transmission of temperature from the hand to a gage. If you think of ten degrees right here, and then think of a thousandth of an inch in ten inches, you have sort of a picture to work on. It doesn't differ much.

We had a case of a shop with a gage like this. One of our girls came in to work on a very cold morning. This gage had been in the shop over night, so it was around 70 degrees. This thing sort of went into reverse. Her hand was colder than the gage. This thing just shot right off the other end. That was the first time I had ever seen it work both ways.

Let me put it this way: If the measurements that you have to control are not less than a tenth, like a quarter or half a thousandth, you probably won't need to worry much about temperature. But if you have dimensions that you have to control that are in tenths, less than half a thousandth, two-tenths, three-tenths, and down, you had better worry about sunlight and getting in a draft.

One other thing I might say is this: I am thinking of temperature around 68 degrees. It doesn't matter whether the shop is 90 degrees provided that the gage and the piece you are measuring and the master you are using are all 90 degrees. The presence of a draft or the nearness of a radiator or something of that nature might throw you off a little.

QUESTION: Would you tell us something about the location of the gage industry, where the plants are located, what their capacity is, how they would support an industrial mobilization, and what their capacity for expansion would be?

MR. KENNEDY: I will tell you this: The majority of the gage industry is located in New England. I will say that. Some of them have spread into western New York and eastern Ohio. Those are two of the larger ones. But there are fifty-odd in New England. Within a radius of forty miles of Providence you will hit most of them.

A P P E N D I X "A"

BOSTON QUALITY CONTROL CONVENTION January 22, 1948

Gaging Clinics

Check list of reminders and questions concerned with choice of gaging methods and selection of equipment.

Why inspect and gage anyway:

- Comparing product with specifications
- Making interchangeable parts
- Reduce assembly cost
- Procure better repair parts
- Reduce scrap, salvage, rework
- Assure final product quality
- Speed up production
- Make work physically easier for operator

Is an inspection or gaging needed at this point?

Can operator gage, inspect, and control quality or must there be an inspector in addition?

Is the gage for the operator alone?

Can inspection and gaging be combined with a later job?

What is initial cost? Does equipment represent a capital investment or is it to be charged as an operating expense to the job?

How is the gaging equipment expected to pay for itself, or must it be used for product protection anyway regardless of immediate savings?

Will the process gaging being planned favorably affect final product quality, repair parts, job scrap and rework?

Are components to be gaged again at some succeeding batch or final inspection, by customer or government inspector?

What class of help will use gageoperator, inspector, supervision; high pay, low pay; high I. Q., moron, blind, crippled; male, female?

Gage to be used at the machine? In a crib, on a bench, at a conveyor, in a temperature controlled room? By roving inspector?

Working conditions: oily, chips, dusty, cold, acid, etc.?

A P P E N D I X "A" (Continued)

Surface measurement.
Automatic gaging machines.
Continuous and strip gaging.
Scales and weighing.
Testing, electrical, oscillograph, stroboscope, etc.
Multiple air gaging.
Selective assembly.
Recording gages.
Masters, standards, spectrometry, etc.

Effects of temperature and surroundings.

Types of measurement.

Outside dimension, as an O. D.
Inside dimension, as an I. D.
Thickness, width.
Depth.
Concentricity or eccentricity.
Straightness.
Squareness.
Angles, curvature.
Taper, out of round, triangle effect.
Location.

Economics and management.

Specification or equivalent--unnecessarily severe?--
effect of product design, of process and methods.

Psychological aspects.
Gage control, labs, maintenance, records.
First cost versus maintenance cost.
The intangible of product reliability.