HIGHWAY RESEARCH RECORD

Number 241

Maintenance Management 1967

7 Reports

Subject Area

12 Personnel Management
40 Maintenance, General

HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

Washington, D.C., 1968

Publication 1629

Price: $2.00

Available from

Highway Research Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

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Foreword

The first three papers in this RECORD describe new techniques being applied to the management of the highway maintenance function; the last four papers are directed to the subject of training, particularly to the defining of training needs in connection with maintenance and ways in which these needs are being satisfied.

Crawford indicates how maintenance (generally considered largely unpredictable) can be planned on the basis of standards for different work activities, related to kinds or classifications of roads. He tells of Louisiana's planning approach which uses quality standards, to establish the level of maintenance to be provided; quantity standards, which set the amount of work requirement; and production standards, which define the resources per unit of work.

Childs, in his paper, deals in some detail with the level of service for maintenance activities—the quality standard. He describes the Ontario Department of Highways method of formulating these standards and training of field personnel in their use in determining maintenance needs.

The Scheer paper discusses the establishment of a new work-reporting system for work activities in Illinois. Most work activities have been defined in measurable units and work accomplishment is reported in terms of these units. Management now knows how much work is done and can evaluate employee performance in terms of man-hours per work unit and unit costs of work.

The McClelland and Lyons paper (an abridgment) is based on extensive studies and research for the Department of the Army in connection with training. It has direct application to the training problems associated with highway maintenance. The paper emphasizes the importance of job definition and performance requirements and de-emphasizes the pedagogical techniques used to accomplish the training.

Bergstralh sets forth a method of determining the training needs of highway maintenance supervisors and the characteristics of those supervisors that have bearing on training. The training needs are limited to the knowledge, skills, and abilities needed for the performance of assigned work. The trainee characteristics include the age, education, experience, learning capability, and attitude variables that affect training.

The maintenance employee training program developed by the Port of New York Authority is described in the Packman paper. The Port Authority provides apprenticeship training for several trades, placing emphasis on effective training materials and training aids, modern training facilities, shop experience, library availability, and motivation.

The Cunliffe paper discusses the results of an approach to highway maintenance employee training in Ontario. Training on the use of salt for snow and ice control was conducted by 20 districts. The subject matter was developed by a committee of maintenance engineers and supervisors from the districts. The training aids and discussion guides were developed by maintenance training specialists in the central office. Almost 60 percent of the persons trained scored at least 75 percent on a post-training test—indicating the effectiveness of the approach.

—Roy E. Jorgensen

Contents

Planning and Programming Highway Maintenance

F. E. CRAWFORD, Louisiana Department of Highways

•HOW do you plan and program an unpredictable operation such as highway maintenance? The amount of snow that will fall or the number of potholes that will develop in the coming year cannot be predicted. Most highway departments plan maintenance on the basis of the previous year's maintenance cost and the money that is available for the next year's budget. Highway maintenance is now costing, nationwide, over $3 billion a year. Planning and programming highway maintenance is a must if departments are to justify their budget requests for funds to state legislatures based on actual needs.

There are many approaches to planning and programming maintenance. The Louisiana Department of Highways, in conjunction with the highway engineering and management consultant firm of Roy Jorgensen and Associates, is developing one approach to the subject. In order to plan work, the following standards first have to be established: quantity, or how much work should be done; quality, how well the work should be done; and production rates, how many man-hours are required. It is also necessary to know what kind of work is to be done and to provide some means for estimating the total amount of work required.

On any road system it is known that in the coming year certain functions, such as patching surface, cleaning culverts, mowing vegetation, and repairing shoulders will require work. The planning unit is set as miles of a road system (interstate, primary, secondary, or farm-to-market) in a geographical area, such as a parish or county. The quantity standard becomes so many acres per mile, cubic yards of aggregate per mile, tons premix material per mile, or miles of ditches to be cleaned per mile. These quantity standards are the average amount of work per mile that will need doing in the coming year and they set the level of maintenance.

Another standard that must be established is production rates. How many man-hours are required to mow an acre or to shape a mile of shoulder? By knowing production rates, man-hour requirements can be planned. If it takes 2.0 man-hours to place a cubic yard of aggregate in surface treatment patching, then on 100 miles of surface-treated roads with a quantity standard of 15 cubic yards per mile, 1,500 cubic yards of aggregate would be needed for the coming year, and it would take 3,000 man-hours to place this material. What the unit cost of material in place on a road should cost can be determined. This unit cost is based on standard work methods with the optimum staffing of men and equipment.

Figure 1 shows how these planning units, quantity standards, production rates, and unit costs are combined on a planning worksheet. It is possible to plan for all the work functions used in maintenance activities. These data summarized by districts and for the entire state become the statewide work plan for the coming year.

The initial work plan is translated into an operation plan. Total quantities shown on the work plan are broken into quarterly quantities according to the seasonal distribution. This quarterly breakdown is a guide to the parish maintenance superintendent in fitting his work schedule to the quarterly plan. The maintenance superintendent schedules his work on a weekly basis. A schedule board is set up showing daily work assignments of foremen and men.

A major requirement of any management system is a reporting system that will furnish all the information needed for management control. For management control

Paper sponsored by Committee on Maintenance Management and presented at the 47th Annual Meeting.

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
MAINTENANCE PLANNING WORKSHEET

Sheet 1

Fiscal Year 1967-68 (1 6) District No. 08 (7 8) Parish No. 35 (9 10) Parish Supt. Gang No. 085 (11 13) Document Code 30 (78 79)

	Function	System	Funct. Code (15 17)	Sy. Code (20)	System Miles (21)	Planning Units (27)	Q./Plan.Unit (33)	M.H./Q. (39 44)	Unit Cost $/Q (46)	Cost Distr. - Percent: Labor (52)	Equip. (55)	Mat. (58)	Contr. Serv. (61)	Seasonal Distr.-Percent: 1st. Quar. (64)	2nd. Quar. (67)	3rd. Quar. (70)	4th. Quar. (73)
BITUMINOUS SURFACE	SURF. TR. PATCHING	Interstate	411	1													
	Plan.Unit = 2-Lane Miles	Primary	411	2	10541	105	100	20	1400	29	15	56		30	20	10	40
	Q = Cu. Yds. Aggregate	Secondary	411	3	10077	100	150	20	1400	29	15	56		30	20	10	40
		Farm-to-Market	411	4	14979	149	100	20	1400	29	15	56		30	20	10	40
	PREMIX PATCHING	Interstate	412	1													
	Plan.Unit = 2-Lane Miles	Primary	412	2	10541	105	40	30	2000	40	20	40		50	20	15	15
	Q = Tons Premix	Secondary	412	3	10077	100	40	30	2000	40	20	40		50	20	15	15
		Farm-to-Market	412	4	14979	149	20	30	2000	40	20	40		50	20	15	15
	PATCHING BASE	Interstate	413	1													
	Plan.Unit = 2-Lane Miles	Primary	413	2	10541	105	20	20	700	60	30	10		35	5	30	30
	Q = Cu. Yds. Material	Secondary	413	3	10077	100	50	20	700	60	30	10		35	5	30	30
		Farm-to-Market	413	4	14979	149	50	20	700	60	30	10		35	5	30	30
	CRACK REPAIR	Interstate	414	1													
	Plan.Unit = 2-Lane Miles	Primary	414	2	10541	69	100	05	180	70	20	10			50	49	1
	Q = Gals. Crack Filler	Secondary	414	3													
		Farm-to-Market	414	4	14979	1	50	05	180	70	20	10			50	49	1
CONCRETE SURFACE	PATCHING SURFACE	Interstate	421	1													
	Plan.Unit = 2-Lane Miles	Primary	421	2	1912	19	150	50	3000	50	20	30		30	50	20	
	Q = Cu. Yds. Concrete	Secondary	421	3													
		Farm-to-Market	421	4	126	1	100	50	3000	50	20	30		30	50	20	
	PREMIX PATCHING	Interstate	422	1													
	Plan.Unit = 2-Lane Miles	Primary	422	2	1912	19	50	30	2000	40	20	40		50	20	15	15
	Q = Tons Premix	Secondary	422	3													
		Farm-to-Market	422	4	126	1	50	30	2000	40	20	40		50	20	15	15
	PATCHING BASE	Interstate	423	1													
	Plan.Unit = 2-Lane Miles	Primary	423	2	1912	19	150	20	700	60	30	10		30	50	20	
	Q = Cu. Yds. Material	Secondary	423	3													
		Farm-to-Market	423	4	126	1	50	20	700	60	30	10		30	50	20	
	CRACK REPAIR	Interstate	424	1													
	Plan.Unit = 2-Lane Miles	Primary	424	2	1912	14	250	05	180	70	20	10			50	49	1
	Q = Gals. Crack Filler	Secondary	424	3													
		Farm-to-Market	424	4	126	1	250	05	180	70	20	10			50	49	1

Figure 1. Maintenance planning worksheet, Louisiana Department of Highways.

LOUISIANA DEPARTMENT OF HIGHWAYS
PERFORMANCE ANALYSIS

Fiscal Year 1967 68
Period From 07 01 67 To 09 30 67

District No. 08 Parish Supt. Gang No. 085 Gang No. SUPT. SUMMARY

FUNCTION NAME	FUNCTION NO	ACCOMPLISHMENT UNIT	QUANTITY	LABOR HOURS	TOTAL COST	UNIT COST STANDARD	UNIT COST ACTUAL	RATE—MH/Q STANDARD	RATE—MH/Q ACTUAL
BITUMINOUS SURFACE									
SURFACE TREAT PATCH	411	CY AGGR	536	1607	9196	1400	1716	20	30
PREMIX PATCHING	412	TONS MIX	603	1847	9751	2000	1617	30	31
PATCHING BASE	413	CY MAT	434	688	2159	700	497	20	16
SEAL COAT	415	SQ YD	54068	352	4807		9		
OTHER BIT SURFACE	419			435	1787				
CONCRETE SURFACE									
PATCHING BASE	423	CY MAT		7	20	700		20	
OTHER CONC SURFACE	429			8	27				
GRAVL-SHELL SURFACE									
PATCHING SURFACE	431	CY AGGR	79	117	563	600	713	7	15
RESHAPE SURFACE	432	ROAD MI	125	220	972	600	778	16	18
SHOULDER + APPROACH									
PATCH NON-PAV SHLDR	441	CY MAT	738	667	2916	358	395	10	9
RESHAP NON-PV SHLDR	442	SHLDR MI	165	444	1985	762	1179	15	27
PATCHING BASE	453	CY MAT	4	6	32		800		15
ROADSIDE + DRAINAGE									
CLEAN-REP DRAIN STR	462			482	1517				
CLEAN-RESHAPE DITCH	463	DITCH MI	1	120	297	60000	29700	2000	1200
MOWING	470	ACRES	4396	3783	12697	350	289	10	9
CUTTING BRUSH	471			2240	4843				
LITTER CLEANING	473	LOADS	15	322	715	4500	4767	200	215
SERV LITTER BARRELS	474	BARRELS	618	219	570		92		4
OTHER ROADSIDE + DR	479			32	68				
STRUCTURE MAINT									
PAINTING STRUCTURES	481	GAL PAINT		40	77				
OTHER STRUCT MAINT	499			24	46				
TRAFFIC SERVICE									
SIGN MAINTENANCE	533			344	660				
BARRICADES+DETOURS	553			24	46				
OTHER TRAFFIC SERV	559			51	120				
DISASTER MAINT									
ACCIDENT DAMAGE	602			132	375				
STATE FORCE CONSTR									
DRAINAGE	622			159	503				
BASE + SURFACE	623			4105	30686				
ROADSIDE DEVELOPMNT	625			98	272				
SIGN INSTALLATION	627			16	31				
MAINT OVERHEAD									
FIELD MAINT OH	651			1048	2886				

Figure 2. Performance analysis report, Louisiana Department of Highways.

of maintenance operations, it is necessary not only to plan work, but also to know how well the actual work complies with the plan.

In Louisiana a revised work-reporting system has been developed. With some revisions, this system follows the AASHO uniform accounting procedures. The function codes were revised, with some codes consolidated and others redefined. A new feature was added—the reporting of the number of accomplishment units of work done during the reporting period. Previously, separate documents were required for labor, equipment, and material, but now all these are combined on the one reporting document. The document is designed for teleprinter transmission to a Univac computer. There will be four primary management reports. These reports are the performance analysis report (Fig. 2), the maintenance performance report (Fig. 3), the productivity analysis, and the maintenance quantity analysis.

A complete changeover to a management system cannot take place in a day. In such a change, the rate of progress is governed to a large degree by how well the manage-

LOUISIANA DEPARTMENT OF HIGHWAYS
MAINTENANCE PERFORMANCE REPORT

FISCAL YEAR 1967-68
PERIOD FROM 9-20-67 TO 12-27-67

DISTRICT NO. 08 PARISH NATCHITOCHES PARISH SUPT. GANG NO. 085

FUNCTION		ACCOMP.	QUANTITY			LABOR HOURS			TOTAL COST			UNIT COST			RATE - M.H./Q.		
NAME	NO.	UNIT	PLAN	ACTUAL	%	PLAN	ACTUAL	%	PLAN	ACTUAL	%	PLAN	ACTUAL	%	PLAN	ACTUAL	%
SURFACE TREAT PATCH	411	CY AGGR	1171	1643	140	2435	3217	132	16921	19578	116	14.45	11.92	82	2.1	2.0	9[illegible]
CRACK REPAIR	415	GAL FILL	596	211	35	119	64	54	423	279	66	0.71	1.32	186	0.2	0.3	150
RESHAP NON-PAV SHLDR	442	SHLDR MI	135	160	118	257	353	137	1026	1408	137	7.60	8.80	115	1.9	2.2	116
MOWING	470	ACRES	2447	1823	74	2933	3361	114	9617	10628	110	3.93	5.82	148	1.2	1.8	150
ETC OTHER PLANNED FUNCTIONS																	
MISCELLANEOUS	699					3648	4449	122	11581	13160	114						
TOTAL PLANNED MAINT						17548	17835	102	55708	56614	102						
RIVER CROSSING OPER							2320			4640							
STATE FORCE CONSTR							1612			11515							
LEAVE							488			976							
ADMIN & OVERHEAD							290			588							
TOTAL STATE SYSTEM							22545			17719							
OFF SYSTEM WORK							855			6112							
TOTAL							23400			80445							

SAMPLE DATA
FOR ILLUSTRATION ONLY

Figure 3. Maintenance performance report, Louisiana Department of Highways.

ment personnel at the district and operating levels understand and accept these new concepts. Training programs are being developed to train supervisors at the operating level. We believe we are on the right track in Louisiana and that our maintenance people will be able to do a much better job under a management system of operation. The allocation of the primary resources of labor, equipment, and people should more closely approximate the maintenance requirements of the highway system.

Highway Maintenance Service Levels

J. M. CHILDS, Department of Highways, Ontario

This report is concerned with maintenance quality levels now being introduced on highways throughout the province of Ontario. The quality standards discussed have resulted from a maintenance management study being undertaken at the Department of Highways, Ontario. The methods of formulating and distributing the standards are given, together with a brief outline of some of the procedures adopted for the training of the maintenance staff.

•THE maintenance management study currently in progress in Ontario is basically an attempt to view maintenance operations objectively and provide managers at all organizational levels with factual data on which decisions can be based. A maintenance management system is being developed, based on the fundamental responsibility of management in planning, organizing, directing, and controlling. Major components of this system are the establishing of levels of service and standards of performance, defining workloads, training of personnel, and reporting of results achieved. The first step in the development of the management system was to set the level of service to be provided by field maintenance personnel by establishing quality standards. These are a quantitative guide to operating personnel and stand as a permanent statement of policy that can be referred to at any time. This paper describes a formalized procedure which has been devised for the development of maintenance quality standards.

THE QUALITY STANDARD

For maintenance purposes, highways are usually divided into a number of administrative units of decreasing size. Thus, the central office will usually have direct control over a number of district or regional offices, each of which will control a number of smaller units. The organizational structure of the Department of Highways, Ontario, is shown in Figure 1. Because at the field or working level there may be several hundred independent work gangs, it is necessary, if control is to be exercised and planning made possible, to insure that each management unit performs like tasks in a similar fashion to produce a similar end product.

Highway maintenance can be compared to a factory production line. Highway maintenance involves mobile work crews operating on a fixed line, whereas on a production line the work units normally remain at a fixed location and the line goes past. The end result, however, should be a product of uniform quality or, in the case of mixed production, products (different classes of highway) conforming to predetermined quality levels. It is necessary therefore to establish the quality or level of service required as a head office policy so that all units in the organization work toward the same end. Quality standards also affect work quantity and may indirectly affect productivity levels. Therefore, setting quality standards forms one vital part of the task of management.

FORMULATING THE MAINTENANCE QUALITY STANDARD

Prior to the preparation of quality standards the Department issued a maintenance manual to field personnel. Although the manual adequately covered most maintenance

Paper sponsored by Committee on Maintenance Management and presented at the 47th Annual Meeting.

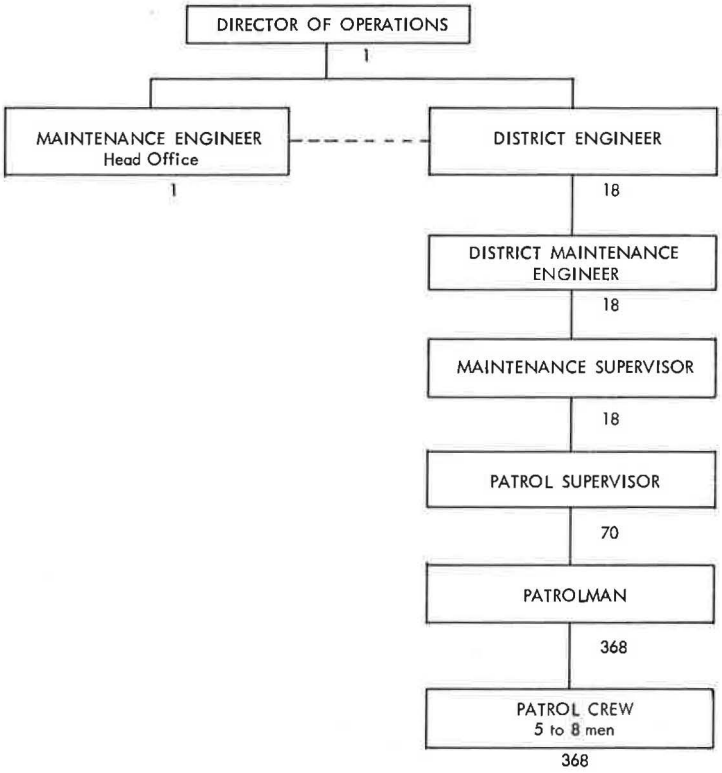


Figure 1. Organizational structure, operations branch, Department of Highways, Ontario.

activities it was formulated by field engineers and was not readily understood by operating personnel.

A panel was appointed to formulate quality standards. The personnel assigned to the panel were experienced field supervisors and engineers. The reasons for this were twofold: first, experienced field personnel insure a practical application of a level of service, and second, standards are more likely to be generally accepted by field supervisors if it is known that experienced field managers produced them.

Standards in draft form were first prepared by head office personnel as a starting point. Subsequent reviews by the panel revealed a wide divergence of opinion on the level of service expected. Reasonable allowable tolerances were set as well as the action to be undertaken when conditions departing from the standards are observed.

Subjective terms such as "pleasing to the eye" and "appropriate height" are not used, since they are open to individual interpretation. An example of a quality standard for guide rail maintenance is given in Appendix A. When it is felt that a standard is in a near-final form it is distributed to a number or random field units. These units review the standard and are interviewed to insure understanding and to further confirm (or deny) the practicability of the documents. These standards must be written in a form that is readily understood by the personnel who have to use them.

In producing quality standards, it is apparent that different service levels will be required for different highways. For example, it is reasonable to expect that a higher level of service will be maintained on a major expressway than on a rural secondary highway. Although these different service levels exist now, a quality standard sets them down in terms. A typical example of difference in quality level applicable to four classes of road is as follows:

WINTER OPERATIONS CONTROL

2. Description

2.1 BARE PAVEMENT—Under this level of service, every effort shall be made to maintain the pavement in a bare condition at all times through the continuous use of all assigned men, equipment, and materials suited to the conditions.

2.1.1 Two highway classifications fall within this level of service:

Class I—Bare pavement level of service applying to all hard-surfaced highways having a winter ADT (average daily traffic) in excess of 1,500 in southern Ontario and 1,200 in northern Ontario.

Class II—Bare pavement level of service applying to all highways having a winter ADT in the range of 500 to 1,500 in southern Ontario and between 400 and 1,200 in northern Ontario.

Note: The distinction between class I bare pavement and class II bare pavement levels of service is that under class I, every effort shall be made to insure that the accumulation of snow on the road surface at any time shall not exceed 1 in.; under class II, the allowable accumulation is 1½ in.

2.2 CENTER BARE—Under this level of service, the attempt shall be made to bare at least the center 6 to 8 ft of pavement within 24 hours of the end of the storm by the continuous use of all assigned men, equipment, and materials suited to the conditions.

Note: When favorable weather prevails, the pavement should be bared for the full width.

2.2.1 The level of service applies to all highways having a winter ADT in the range of 250 to 500 in southern Ontario and from 200 to 400 in northern Ontario.

2.3 SNOWPACKED—Under this level of service the attempt shall be made to maintain the road surface in a snowpacked condition—or better if paved—by the use of assigned men, equipment, and materials suited to the conditions.

Note: On snowpacked gravel roads, raw chemicals shall not be used for snow and ice control.

2.3.1 This level of service applies to all highways having a winter ADT of less than 250 in southern Ontario and less than 200 in northern Ontario.

DISTRIBUTION OF A STANDARD

Various procedures were attempted in the distribution of standards. After the initial distribution, interviews with the field manager responsible for a specific section of the highway system revealed that in a number of cases the desired level of understanding had not been achieved and in other instances the standard had not even been read.

A new procedure was developed which, it was felt, would overcome these problems. Head office personnel who were thoroughly familiar with a specific standard held regional meetings with small groups of district supervisors. These small groups discussed the individual standards in detail. The district supervisors attending these meetings then held similar discussions with patrol supervisors who supervise four to six patrolmen. These patrol supervisors, in turn, had the responsibility for assuring that the individual patrolmen were fully informed of the standards.

A further refinement to the distribution procedures was made to eliminate the necessity for the initial discussion between head office and district personnel. Each district maintenance engineer receives standards as they are issued and then meets with his maintenance supervisor and patrol supervisors to examine and discuss the standard in detail. The patrol supervisors hold similar meetings with patrolmen under their jurisdiction.

FEEDBACK

Shortly after these meetings, a post-training test is presented to each patrolman. No restriction is placed on the use of the appropriate quality standard as a reference.

The test is designed to emphasize the key points of the standard and to amplify critical areas.

After completion of the test questionnaire, each patrolman is required to compare his answers with those on an answer sheet given to him by the patrol supervisor. He then corrects any wrong answers and discusses any points of misunderstanding with his patrol supervisor. The completed questionnaires are examined by the district maintenance engineer to insure that all of his patrolmen have completed the training. The questionnaires are then forwarded to the head office for analysis by the training group. Each patrolman inserts the answer sheet, which is identical to the questionnaire, in his quality standards manual for future reference. An example of the questionnaire for cable guide rail is given in Appendix B.

A detailed study of the completed questionnaires should indicate any part of a standard which requires clarification or modification. This type of feedback will insure the desired understanding with the result that realistic levels of service will be provided to the field forces.

MAINTAINING THE REQUIRED SERVICE LEVEL

The entire process is flexible so that there is always room for change. Revisions to a standard are easily made and disseminated to the field staff in a form which is readily understood.

This approach currently used in the preparation of a specific standard, the procedure followed in distribution, the post-testing of field personnel, and subsequent analysis of the results should insure that the objective of providing simple statements of policy to field forces will be met.

To insure that the required service levels are maintained, the department is training personnel and issuing operating instructions which will provide a step-by-step description of the best method of performing an activity. A reporting system is being devised which will require the full reporting of the actual level of accomplishment attained.

Appendix A

TYPICAL EXAMPLE OF A QUALITY STANDARD
(sample pages follow)

QUALITY STANDARD D. H. O. STD. M. 606-1

CABLE GUIDE RAIL

ISSUE NO. 1 DATE OF ISSUE: Jan. 1967 PAGE 1 OF 6

RECOMMENDED: _____ APPROVED: _____

Maintenance Management Engineer MAINTENANCE ENGINEER

1. DESCRIPTION

1.1 Cable Guide Rails consist of single rows of wooden posts supporting a single or double cable. They define the location of hazardous curves and high fills.

These photos are examples of correctly installed guide rails.

2. INSTALLATION, REMOVAL OR RECONSTRUCTION

2.1 New installations, permanent removal or complete reconstruction of any section of Cable Guide Rail shall not be undertaken without the approval of the District Engineer.

2.2 All installations of Cable Guide Rails approved by the District Engineer shall be constructed in accordance with Department of Highways Standard DD-902 (attached).

Note that tops of posts are not cut to the proper angle. See Std. DD-902.

3. INSPECTION AND REPAIR

3. 1 All Cable Guide Rails shall be carefully inspected each Spring for the following defects; remedial action shall be taken by the Patrolman as required:

3. 1. 1 Check that supporting posts are not out of plumb by more than 3 inches in 3 feet. Realign if required.

Does not meet Standard 3. 1. 1

3. 1. 2 Check that the post height above the ground-line is not less than 27 inches. Re-install or replace, if required.

3. 1. 3 Check that all cables are from 24 inches to 27 inches above the ground-line and are properly secured to the guide-posts with 6 inch spikes or 3 inch staples. Effect Repairs, as required.

Does not meet Standards 3. 1. 2 and 3. 1. 3

3. 1. 4 Check that the tops of the posts are not out of alignment with the general line of the Guide Rail by more than 3 inches. Realign if required.

Does not meet Standard 3. 1. 4

3. 1. 5 Check that all posts are sound and set solidly in the ground. Damaged or missing posts shall be replaced as soon as possible with permanent wooden posts or with temporary steel posts and delineators. Permanent repairs, including painting, shall be made as soon as weather and ground conditions permit.

Above photo shows remedial action to be taken if posts are damaged by accident.

3. 1. 6 Check that cables are not frayed or badly rusted. Replace if necessary.

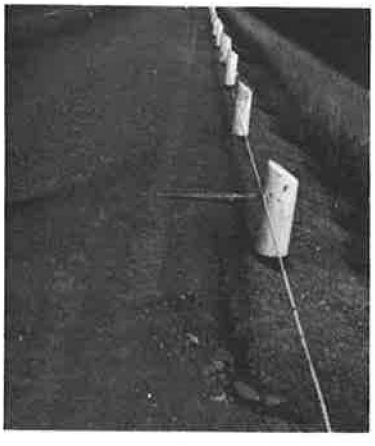
3. 1. 7 Check that all cables are tight and secure. Tighten if necessary so that no cable sag is visible.

Above photo shows guide rail not meeting Standards 3. 1. 4, 3. 1. 6 and 3. 1. 7. Note tops of posts are of varying heights, and are not chamfered or cut to the proper angle.

3.1.8 Check that all reflective strips are clean and in good condition. Check that the location and position of the strips conforms to the requirements of Standard DD-902. Replace defective strips in accordance with Standard DD-902.

Does not meet Standard 3.1.8. Reflective strips are in wrong position. Note also that a double intermediate brace panel is missing. See Standard DD-902.

3.1.9 Check Guide Rail for gravel windrow. Remove windrow if present.



Note the result of leaving a gravel windrow. Washouts such as this can be avoided by removal of any windrow caused by grading of shoulders.

3. 1. 10 Check sections of Guide Rail that may need painting. If more than one-quarter of the Guide Rail paint is missing, it shall be completely re-painted according to paragraph 4. 1.

Does not meet Standard 3. 1. 10. Note also that cable is loose and tops of posts not at a uniform height.

4. **PAINTING**

4. 1 Guide Rail posts shall be thoroughly clean and dry before painting. (Do not clean unless posts are to be painted within two weeks.)

4. 1. 1 All Guide Rail posts shall be painted with white paint. Central Stores Code No. 16-2-21-1. (Exception: Q. E. W.)

4. 1. 2 Paint each post down to the ground line. Reflective strips and cables shall not be removed or painted.

A freshly painted post that was not painted to the ground-line Standard 4. 1. 2.

Does not meet Standards:

3. 1. 5 - damaged posts
3. 1. 7 - cable not secure or tight
3. 1. 8 - reflective strip missing
3. 1. 9 - gravel windrow present
3. 1. 10 - posts need painting

5. DAMAGE TO CABLE GUIDE RAILS

5. 1 The Patrolman shall report all damage to Guide Rails to the District Office. He shall also check with the local O. P. P. Detachment for details for the person(s) responsible for the damage and report this information to the District Office immediately on the appropriate form.

Guide Rail damage by an accident. Temporary repairs performed, missing posts to be installed as soon as conditions permit.

IDEAL INSTALLATION

Appendix B

MAINTENANCE STANDARD QUESTIONNAIRE

1. Guide rail is checked visually every day as part of the routine road patrol. Guide rail is also checked thoroughly at a set time during the year. This is an on the ground, post by post, type of inspection.

   Which of the following is correct?

   (Mark with a ✔)

   This thorough inspection is carried out:-

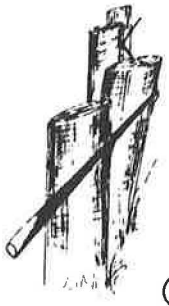
   - Every other day ☐
   - Once a year, in the spring ☑
   - Once a year, in the fall ☐
   - Twice a year, in the spring and fall ☐
   - Once a year, in the winter ☐
   - In the morning, on pay day ☐
   - The first working day of each month ☐
   - Twice each summer ☐

2. Using the Quality Standard as a guide, list the things that should be checked during this major inspection. Use your own words. Add anything you think should be checked that is not shown in the Quality Standard. If more space is required, use the back page.

Check that posts are not out of plumb
Check that posts are at least 27 ins. high (above ground)
Check that cable is from 24 in. to 27 in. high (above ground)
Check that posts are not out of alignment
Check that posts are undamaged and are solidly set in the ground
Check that cables are sound and not excessively rusty.
Check that cable is tight
Check reflectorized strips for location and condition
Check for gravel windrow
Check to see if posts require painting

3. In the following illustrations, the posts marked A and B require correction.

Ⓐ



Ⓑ

Mark which of the following answers are correct.
If you do not know the answer, please do not guess.

Ⓐ is out of plumb	☐	Ⓑ is out of plumb	☑
Ⓐ is out of alignment	☑	Ⓑ is out of alignment	☐

4. Mark the following questions True or False:-

	True	False
Reflectorized strips and cables should be removed from the posts before painting	☐	☑
Posts should be painted white right down to the ground	☑	☐
Posts should be at least 27" above the ground in height	☑	☐
Posts should be painted when more than ½ of the old paint has peeled or worn off	☐	☑
Temporary repairs should be made to damaged guide rail when permanent repairs cannot be made immediately	☑	☐
It is not necessary to clean a post before painting unless the post is obviously dirty	☐	☑
For 2 lane highways, the reflectorized strips on guide rail posts should be 15" by 4" in size	☑	☐

5. Besides making immediate repairs, what other action should be taken when guide rail is damaged by an accident.

(i) Report damage to District Office

(ii) Check with Ontario Provincial Police for details, particularly name and address of person responsible for damage.

6. Mark the following questions True or False.

The District Office must be notified:-	True	False
Before any work is done on guide rail	☐	☑
Before new guide rail is installed	☑	☐
Before any emergency work is done on guide rail	☐	☑
After guide rail is damaged in an accident	☑	☐
Before sections of guide rail are removed	☑	☐
Before guide rail posts are painted	☐	☑
Before any major re-construction of guide rail	☑	☐

7. Repairs to guide rail can be separated into two groups:-

   (i) Routine
   (ii) Urgent

   Urgent repairs should be carried out as soon as time and weather permit. Routine repairs should be scheduled throughout the season to take best advantage of staff and equipment.

   On the following chart, check those items which you think are Routine and those which you think are Urgent.

	Routine	Urgent
Tighten loose cable	☑	☐
Paint posts	☑	☐
Replace broken posts	☐	☑
Replace destroyed reflectorized strips	☐	☑
Remove windrow	☑	☐
Re-align posts	☑	☐
Replace broken cable	☐	☑

8. What is Department of Highways Standard DD-902?

   DD-902 is the construction standard for post and cable guide rail.

   What is Department of Highways Standard M-606-1?

   M-601-1 is the maintenance quality standard for post and cable guide rail.

An Approach to Performance Rating

H. O. SCHEER, Engineer of Maintenance, Illinois Division of Highways

•DETAILED and current data of maintenance expenditures are a prime requirement in sensible programming and directing of maintenance work. In the past, in Illinois (and I am sure in many other states), maintenance expenditures were gathered and reported annually in cost per mile regardless of type of road, traffic, and other such items. Historical cost data, which should have been of considerable assistance in projecting future maintenance needs, could not be utilized because the performance data were not known. In other words, we knew the amount of money we spent but we did not know how much work was accomplished with that money. A sound standard did not exist for measuring the adequacy of maintenance, and maintenance engineers within the state varied in their opinions as to what was a standard of adequacy.

A study was made several years ago in an attempt to set up a standard of maintenance. It was decided that the standard of maintenance depended largely on the amount of money that was available and also on the volume of traffic using the highway facility. In 1965, a study was started in Illinois to develop a reliable method of reporting maintenance costs and accomplishments. In the past, we had known how much money was spent, but we did not know for sure where it was spent and for what, except in general terms. This new system was put into effect July 1, 1967, and we believe it will provide information necessary for proper management and for measuring the performance of our employees.

We have 11 general categories of work items, subdivided into 47 individual work items. A section man or foreman now not only reports the number of hours his crew puts in, but also what they accomplished. Bituminous patching is reported in tons; permanent replacement of PCC pavement, in square yards; crack-filling, in gallons of asphalt; bump-burning and joint-cutting, in lineal feet; mud-jacking and undersealing, in cubic yards; sealing, in square yards; shoulder-patching, in tons of material used; shoulder-grading, in cubic yards; ditch-cleaning, in cubic yards; mowing and spraying, in acres; cleaning dirt and debris, by lane miles; snow removal, by equipment hours; erection of snow fence, by lineal feet; and repairing and maintaining guardrail, by lineal feet. However, there are some maintenance items that cannot be reported in units of work accomplished, such as the maintenance of rest areas, repairing and maintaining weigh scales, subway pumping, general duties, and loss time. It was not difficult for a man to report how many lineal feet of guard fence he painted or repaired or how many acres he mowed, since this is easily determined. We realized that in items involving material, such as blacktop patching, we would have to estimate, to some extent, the amount of material used. Our employees were instructed that a certain size truckbed, level full, will hold so many tons of material. The employee would then estimate, knowing the maximum capacity of his bed, how much of a fraction of the full bed he used. This, it would appear, permitted a man to cheat by reporting an excess use of material to make his accomplishment seem greater.

Each quarter, a cost report is prepared for supervisory personnel. This cost report shows the amounts expended for materials, labor, and expenses during that quarter on each subsection. This serves not only to tell how much was spent, but to check the accuracy of the employee reporting on his subsection. That is, he might report he had used 50 tons of bituminous material when actually only 10 tons were paid for during that quarter and charged to his subsection. The men know this and realize that it

Paper sponsored by Committee on Maintenance Management and presented at the 47th Annual Meeting.

might be embarrassing if they were asked why they reported using a large amount of material when only a small amount was purchased.

The information obtained from our time cards is fed into the computer, and reports are developed at the end of each month showing how much was accomplished on each section during that month. This report shows the work accomplished in work units, the labor hours in man hours, the factor of man hours per work units, and the cost per units. Reports are furnished to supervisory personnel for each unit under their jurisdiction. A report is also furnished the supervisor which shows the work units for each crew under him. The field engineer receives the report on each of the individual crews and he can easily compare the work accomplished by each crew and thereby rate the performance of the individual crews. The district maintenance engineer receives a report showing the work accomplished in each field engineer's territory by work functions. Through this, he can determine the performance of each of the engineers. In my office, I receive a report which shows the accomplishments of each of the districts and I can thereby compare the performance of individual districts against each other.

Realizing that the workload of one section of road varies considerably with another section due to age, traffic volume, topography, and other such items, we made a physical inventory of the entire highway system. This inventory includes the lineal feet of guardrail, the number of entrances, culverts, lane miles of pavement by width, the acres of right-of-way to be mowed, width of right-of-way, and all other such individual items that make up the entire highway structure. Our maintenance sections are divided into subsections. A subsection is continuous length of a marked route within the limits of a maintenance section. A maintenance section might have only one subsection or it might have three or four. This inventory is made by subsections, and so we know what each subsection has in its maintenance requirements. Through this inventory we can evaluate the workload of one maintenance section against another, and of one field engineer's area or one district against another.

The method I have briefly described will, in time, give us a very good method of performance rating for the various maintenance crews and districts in Illinois.

Guidelines for Manpower Training as Developed by the Human Resources Research Office of the George Washington University

WILLIAM A. McCLELLAND and J. DANIEL LYONS, George Washington University

ABRIDGMENT

•THE systematic, generalized procedure for building and evaluating training courses, which has evolved from HumRRO research, consists of the following seven steps:

1. Determine job performances required.
2. Devise training objectives from job performance requirements.
3. Base training content on training objectives.
4. Select appropriate training methods.
5. Administer training appropriately.
6. Monitor the trained product.
7. Modify training as required.

The most critical of these steps is the determination of job requirements, based on the system requirements.

A useful procedure for the selection and sequencing course content is functional context training, in which the student proceeds through a graded series of job-related tasks. One of the primary advantages of this procedure is that it enhances the probability that the training will, in fact, be job-relevant.

The major characteristics of HumRRO research on maintenance training are as follows:

1. Development of a generalized approach for training course development,
2. Emphasis on job requirements,
3. Orientation toward troubleshooting behavior, and
4. Development of improved manuals and job aids.

The basic questions which must be addressed in conducting research on a training course concern the job requirements, proficiency assessments, training methods, training aids, and job aids. Improvement in training can more often be achieved by revision of course content than by improvement in pedagogical procedures.

Paper sponsored by Committee on Maintenance Personnel and presented at the 47th Annual Meeting.

Methods Employed in Conducting a Training Needs Study in a Maintenance Division of a State Highway Department

KERMIT L. BERGSTRALH, Roy Jorgensen Associates

Valid measures of training needs are made for current and potential maintenance supervisors. They reveal the most urgent needs and the best course content and form for training.

Maintenance subject matter experts and experts in study techniques work as a team to accomplish the following:

1. Ascertain the status of the total supervisory force on factors that affect learning, using employer records to find age, education, experience, and geographic distribution factors.
2. Break down the tasks of each maintenance job and list them in job element statements, to reveal the knowledge, skills, and abilities needed to do the job, which are then combined into KSA statements.
3. Measure how well a random sample of supervisors possesses the knowledge, skills, and abilities needed in their jobs; KSA-based written tests, performance tests, and supervisory appraisals are used and results are projected statewide to find the total number needing training on that KSA.
4. Measure the sample supervisors for their capacity to learn, using a standard test, and using questionnaires and interviews to see if they are willing and have time to take training.

•THE objective of this paper is to present a technique that can be used to identify the training needs of highway maintenance supervisors and to develop a plan for training those supervisors.

Three subordinate objectives are involved—

1. To identify the training needs of the maintenance supervisors,
2. To identify the characteristics of the maintenance supervisors that will have bearing on their training, and
3. To use the training needs data and the supervisor characteristics data, together with current training technology, in developing the plan for training maintenance supervisors.

TRAINING NEEDS IDENTIFICATION PROCEDURE

Identification of the training needs of maintenance supervisors involves four steps: (a) development of a survey organization, (b) identification of the work performed by the maintenance supervisors, (c) identification of the knowledge, skills, and abilities (KSA) needed to perform the work, and (d) identification of the extent to which current supervisors and potential future supervisors have the knowledge, skills, and abilities needed to perform the work. Any lack of required KSA constitutes a training need.

Paper sponsored by Committee on Maintenance Personnel and presented at the 47th Annual Meeting.

Survey Organization

The organization required to conduct a training needs survey includes a training needs committee and a project staff.

Training Needs Committee—Persons thoroughly knowledgeable about the specific activities performed by maintenance supervisors are needed for service on a training needs committee. The committee members, as a group, are responsible for defining the work performed by maintenance supervisors, and the knowledge, skills, and abilities needed for satisfactory work performance. They are further responsible for developing tests and other measures used to identify the extent to which individuals actually possess the required KSA.

Project Staff—Two persons are needed on the project staff; both should have specialized knowledge about training. They are responsible for conducting the committee meetings, for collecting and classifying the work data and the KSA data, and for developing the survey materials. They are also responsible for tabulating and interpreting the results, and for developing a recommended plan for training.

Identification of Work Performed

Persons are employed to perform work. It is necessary, then, to analyze the work itself to identify the knowledge, skills, and abilities needed to do the work. Analysis of the work performed by maintenance supervisors (and by almost any group of employees) involves identification of the major elements of the work and of the specific tasks that make up those elements.

Job Elements—The maintenance of roads and bridges involves, among other things, the repairing of subbases and bases, asphalt surfaces, concrete pavements, and structures. Each of these activities can be considered a job element—a definable segment of the work performed.

Job Element Tasks—A task, as the term is used herein, is a unit of work performed in connection with a job element. For example, among the tasks performed in connection with base and subbase repair are (a) the location of the repair work to be made, (b) identification of the materials involved, and (c) calculation of the quantities of materials needed. All significant tasks performed in connection with each job element are identified so that the KSA needed for their performance can be determined.

Job Element Statements—A typical job element statement, that for base and subbase repair, is as follows:

Department of Highways
Maintenance

Job Element Statement
Number 2

BASE AND SUBBASE REPAIR

Scope

The repairing of base and subbase structures.

Tasks

1. Identify the location of needed repairs and the extent of each need.
2. Identify the type of base involved: soil cement, iron ore, concrete pavement, soil, lime treated soil, or sand, clay, gravel.
3. Calculate the quantities of materials required.
4. Locate the source of materials.
5. Plan and initiate the operation:
   Organize manpower and equipment,
   Make individual work assignments,
   Load materials,
   Proceed to work site.

6. Supervise the performance of work at the job site:
   Remove the defective base section,
   Replace the removed material,
   Compact the material,
   Shape up the base,
   Clean up the work site.
7. Prepare records of materials, equipment, and manpower used.

A job element statement reflects a major activity that can be isolated from all other work activities for analysis purposes. The tasks listed are set forth only in such detail as is necessary to indicate the knowledge, skills, and abilities needed for their performance.

Job Element Series—A typical list of job element statements, developed to identify the work performed by maintenance supervisors, is as follows:

1. Asphalt surface repair
2. Base and subbase repair
3. Bridge painting
4. Bridge repair
5. Concrete pavement repair
6. Concrete structures repair
7. Ditch cleaning and shaping
8. Drainage equipment maintenance
9. Equipment maintenance—field
10. Equipment maintenance—shop
11. Fence installation and maintenance
12. Gravel road conditioning
13. Guardrail installation and maintenance
14. Mudjack operation
15. Park maintenance
16. Pavement marking
17. Pipe placement
18. Rest area construction
19. Right-of-way clean-up
20. Roadside mowing
21. Roadside forestry
22. Shoulder and slope maintenance
23. Sign fabrication
24. Sign placement
25. Snow and ice control

Identification of KSA's Required

Each task requires the possession of knowledge and ability for its performance, and some tasks require skill—a term used in this paper to mean unusual ability with tools or equipment. So that these knowledge, skill, and ability requirements can be treated meaningfully from a training standpoint, they must be identified, defined, and classified.

KSA Identification—To calculate the quantities of materials required to repair a subbase structure, it is necessary to be able to work with whole and decimal numbers and to know the formulas for volumes. If two or more materials are to be used, it is necessary also to know the types of materials and how they will behave when mixed with each other. Each task in each job element is analyzed in this way.

KSA Definition—Each requirement of knowledge, of skill, and of ability includes everything needed, but is limited to that actually needed, for satisfactory work performance. If the employee must be able to add and subtract whole and decimal numbers

and to calculate areas and volumes, the defined requirement includes, and is limited to, these abilities.

KSA Classification—As each increment of knowledge, skill, and ability is defined, it is combined with others of its kind and classified so that all can be treated meaningfully in terms of training needs identification and training materials development.

Two types of KSA's are developed. The first represents a combination of knowledge, skills, and abilities used by almost all maintenance supervisors, as illustrated in the typical KSA statement that follows:

Department of Highways
Maintenance

KSA Statement
Number 4

MATHEMATICS

ADDITION, SUBTRACTION, MULTIPLICATION AND DIVISION

Knowledge

1. Of the relationships between whole numbers, decimals, fractions, and percents.
2. Of the rules that apply in listing whole, fractional, and decimal numbers in order to add or subtract.
3. Of the rules that apply in the placement of whole, fractional, and decimal numbers before they can be multiplied or divided.

Skill

None

Ability

1. To work with whole, fractional, and decimal numbers in calculating quantities, grades, and elevations for road and bridge maintenance work.
2. To convert fractions to decimals and decimals to fractions.
3. To relate numbers to each other as ratios.

The second represents a combination used only by certain supervisors—in this case, those responsible for making base repairs. A typical KSA statement illustrating this type is as follows:

Department of Highways
Maintenance

KSA Statement
Number 30

BASE REPAIRING

Knowledge

1. Of the functions of the base structure of a road.
2. Of the Department standards and specifications applicable to the construction and reconstruction of base structures.
3. Of what constitutes base failure, what causes base failure, and what indicates base failure.
4. Of the different types of bases used: soil and clay; lime or oil treated soil and clay; soil cement; iron ore, shell, gravel; portland cement; and asphalt.
5. Of the equipment used to make base and subbase repairs, and the capabilities of that equipment: draglines, gradalls, motor graders, rollers, tampers, seaman stabilizers, air compressors and hammers, and pull tractors.
6. Of the methods of operation involved in excavating, moving, and placing of rock, soil aggregates, shell, iron ore, and additives to reconstruct base and subbase sections.
7. Of soil density and compaction requirements.

8. Of the special methods and requirements involved in the placement of earth under and in support of drainage pipes and culverts.
9. Of the need to provide for the proper drainage of base structures.
10. Of the special records and reports applicable to base and subbase repairs.

Skill

1. In the use of the specialized tools and the operation of the specialized equipment involved.

Ability

1. To recognize and evaluate the conditions that indicate subbase and base failures, and the extent of such failures.
2. To plan, organize, and supervise the work involved in making repairs to subbase and base structures.
3. To insure that the materials to be used have been sampled and tested and continue to be suitable.
4. To inspect the methods used and the workmanship to insure compliance with adopted procedures and standards and achievement of the desired result.

KSA Guidelines—Four guidelines are followed in classifying knowledge, skills, and abilities for training needs analysis purposes:

1. Each classification describes a single combination of knowledge, skills, and abilities needed for the performance of work.
2. Each single combination is made as broad as possible, but not so broad as to require a significant number of persons to know and to be able to do things not required for the performance of their assigned work. Example: Certain supervisors need to add, subtract, multiply, and divide. Others need to do this and to calculate areas and volumes. Two KSA's are developed to avoid requiring the first group to take training in area and volume calculation.
3. Each combination overlaps the other KSA combination as little as possible. Example: the ability to add and subtract is not included in each KSA where the ability applies.
4. The total series of KSA combinations contains all of the knowledge, skills, and abilities required for accomplishment of all of the work, regardless of the numbers of persons, levels of authority, or numbers of organization units involved.

KSA Series—A typical list of KSA statement titles applicable to maintenance supervisors is as follows:

KSA Statement Title	KSA Number
Basic Group	
Department, division, and district orientation	1
Maintenance function orientation	2
Terms appropriate to maintenance	3
Mathematics—Addition, subtraction, multiplication, and division	4
Equipment—Functions and capacities	5
Equipment—Service	6
Soil and aggregate mixes	7
Portland cement concrete mixes	8
Asphaltic materials	9
Road and bridge maintenance standards	10
Record keeping and reporting	11
Manuals of reference	12
Public relations	13
Communications	14

KSA Statement Title (continued)	KSA Number
Basic Group	
Training—On-the-job	15
Supervision	16
Painting wood, metal, and concrete	17
Inspection of roads and bridges	18
Right-of-way clean-up	19
Snow and ice control	20
Emergency and disaster work	21
Traffic safety activities	22
Utility company contact work	23
Specialized Group	
Contract plan interpretation	24
Blueprint interpretation	25
Mathematics—Areas and volumes appropriate to maintenance work	26
Basic survey (rod and chain work)	27
Intermediate surveying (elevation and alignment work)	28
Excavating and embanking	29
Base repairing	30
Gravel road repairing	31
Asphalt surface patching	32
Asphalt surface leveling and sealing	33
Portland cement concrete repairing	34
Mudjacking	35
Drainage equipment repairing	36
Pipe placing	37
Small concrete structure repairing	38
Roadside mowing	39
Roadside forestry work	40
Guardrail and fence maintenance	41
Bridge repairing	42
Bridge painting	43
Sign painting	44
Sign placement	45
Center and edge-line painting	46
Signal and light maintenance	47
Equipment maintenance—field	48
Equipment maintenance—shop	49
Advanced Group	
First level management	50

No one person needs to know and be able to do all that is represented by the 50 KSA's. Individuals need only to know those things required by their own work assignments. Still, at least one person must know and be able to do all that is represented in each KSA, since each KSA reflects part of the total body of knowledge, skills, and abilities needed to supervise the maintenance of roads and bridges.

The information in the above list indicates that (a) the knowledge, skills, and abilities needed by maintenance supervisors can be classified for training purposes, (b) the various combinations range from initial orientation to the application of management principles and practices, and (c) the majority of combinations reflect the technical aspects of road and bridge maintenance work.

KSA Groups—The 50 KSA statements listed above are placed in three groups: the basic KSA's, the specialized KSA's and the advanced KSA's. The basic KSA group includes 23 KSA's. All maintenance supervisors need to know and to be able to do that which is represented by these 23 KSA's. The specialized KSA group includes 26 KSA's. Individual supervisors need to know and to be able to do only those things set forth in the KSA's that apply to their current work assignments or will apply to their upcoming assignments. One KSA, that for first level management, has been placed in the advanced KSA group. Only persons responsible for planning, organizing, scheduling, directing, and controlling work on a district-wide basis are expected to know and to be able to do those things represented by this KSA. (The advanced group typically contains two additional KSA's, those representing the knowledge, skills, and abilities needed at the middle management and top management levels of the maintenance function.)

Identification of Training Needs

The maintenance supervisors, as a group, must possess the knowledge, skills, and abilities represented by the 50 KSA statements. All supervisors must know and be able to do that which is represented by the 23 basic KSA's. Individual supervisors must know and be able to do that which is represented by one or more specialized and advanced KSA's. Any lack of required knowledge, skills, and abilities represents a training need.

Four steps are taken to identify the training needs among current and future maintenance supervisors:

1. Individual and potential supervisors are selected at random to represent, as samples, the personnel included in the training needs survey.
2. Tests are used to determine the extent to which the individuals in the samples possess the knowledge, skills, and abilities needed in the performance of their assignments.
3. Evaluations and appraisals are used instead of tests in connection with KSA combinations that do not lend themselves to testing.
4. Test, evaluation, and appraisal results are projected to obtain indications of the training needs of the supervisory and potential supervisory personnel represented by the samples.

Typical Sample—For purposes of this paper, it is assumed that 200 persons are employed as maintenance supervisors, and 800 are employed in the subordinate positions from which future supervisors will be selected.

So that the training needs of these two groups can be identified without testing and appraising each individual, two samples of employees are selected. Table 1 gives a typical

TABLE 1

TYPICAL DISTRIBUTIONS OF MAINTENANCE SUPERVISORS AND POTENTIAL SUPERVISORS, AND TYPICAL SAMPLES FROM EACH GROUP

Personnel Category	Statewide Force		Training Needs Sample		
	Number in Group	Percent of Group	Number in Group	Percent of Group	Percent of Statewide Force
Supervisors					
Foreman IV	10	5	6	8.5	
Foreman III	30	15	12	17.0	
Foreman II	60	30	20	28.5	
Foreman I	100	50	32	46.0	
Group total	200	100	70	100	35
Potential Supervisors					
Equipment operator IV	40	5	8	10.0	
Equipment operator III	80	10	12	15.0	
Maintenance man II	620	77.5	50	62.5	
Mechanic III	60	7.5	10	12.5	
Group total	800	100	80	100	10
Total	1000		150		15

distribution of supervisors and potential supervisors, and a typical sample selected from each group.

As indicated by the data in Table 1, the sample groups must be reasonably comparable to the employee groups they represent. If the total force is small, the sample must be relatively large, as when 60 percent of the Foremen IV are selected to represent the 10-man Foreman IV classification. If the total force is large, the sample group can be small, as when 50 persons are selected to represent the 620-man force of Maintenance Men II.

If the total supervisor force includes, say, 70 persons or less, it is worthwhile to test and appraise the total force. If the force contains upwards of 200 persons, a sample probably provides more accurate data than can be obtained by testing and appraising the total force. If the force includes upwards of 1000 persons, an 8 to 12 percent sample is adequate and manageable.

Testing—Most maintenance supervisors have been out of school for several years, many of them for 30 years or more. Tests used with such persons must be designed to insure the testing of knowledge, skills, and abilities needed to do work, not knowledge, skills, and abilities needed to take tests. Most superiors have evaluated subordinates for purposes of salary increases and promotions. Evaluation systems used to identify training needs must be designed to overcome previous conditioning, if training needs rather than other characteristics are to be identified by evaluation. Finally, tests and evaluations are effective in relation to certain KSA's only. Others, such as supervisory skill and public relations ability, probably are best appraised by the individuals themselves.

The most reliable indications of individual training needs are the objective indications obtainable through tests, as compared to the subjective indications obtained through evaluations and appraisals. Testing is preferred to evaluating and appraising—but only to the extent that valid and reliable tests can be developed.

Just as tests are preferred to evaluations and appraisals, performance tests are preferred to written tests. If a supervisor can perform a part of his work and thereby demonstrate his ability to do the work, he can show clearly his lack of a training need. If he cannot perform a part of his work in the test situation, it can be assumed that he has a training need. Some typical performance tests, if they are called for in the work situation, include establishing slopes on shoulders or ditches, and preparing or identifying batches of asphalt mix.

Typical questions used in maintenance supervisor training needs tests are shown below:

Basic Mathematics

1. Add the following numbers and fractions: $6 + 3\frac{1}{2} + 3.5$
2. $6\frac{1}{2}$ tanks of asphalt were used. The tank held 600 gallons. The asphalt cost 10 cents per gallon. What was the cost of the asphalt used?

Asphalt

1. Two types of asphalt have been placed on the Monitor's table. Name the two types.

Soils and Aggregates

1. Four samples of aggregate have been placed on the Monitor's table. Name the aggregate in each pan.

Manuals of Reference

Use the manuals provided by the Monitor to answer the following questions:

1. Where would you find instructions on how often to mow grass on the right-of-way?

   Name the manual _____

   Give the page number _____

The questions are short, clear, and highly job-related. Where possible, the written questions approach the performance type, as when the individual is asked to use a manual of reference in much the same way as he would use it in the work situation.

Written and performance questions are developed by persons having specialized knowledge about the work (the training needs committee) and edited by persons having specialized knowledge about testing (the project staff personnel). Care is taken to insure that the words, sentences, and sketches are appropriate to the education and reading levels of most participants.

So that each supervisor in the sample is tested and appraised in relation to the KSA's that apply to his own work assignments, his immediate superior identifies two groups of applicable specialized and advanced KSA's: those that apply to work assignments performed within the past two years, and those that apply to work assignments to be performed within the next year. So that each potential supervisor in the sample is tested and appraised in relation to the specialized and advanced KSA's that will apply to his first assignments as a supervisor, his superior identifies the KSA's most likely to be applicable during the first year after promotion. The supervisors and potential supervisors are then tested and appraised in relation to all of the 23 basic KSA's plus each applicable specialized and advanced KSA.

Persons tested are permitted to use any books, tools, and equipment available to them in the normal course of their work. Further, they are permitted to do anything that will help them overcome any apprehensions they may have about the tests—except what would indicate they know answers they do not know, or have skills that they do not have. Their deficiencies represent their own trainings and the training needs of others in the total employee force.

Tests are organized so that each test section represents a specific KSA. The test sections are scored as follows:

> A score of 1 represents a training need in connection with the respective KSA that should be fulfilled by specific employer action.
> A score of 2 represents a training need of low priority, one that can be fulfilled when materials are developed for other persons more seriously in need.
> A score of 3 represents possession of the knowledge, skills, and abilities needed for satisfactory work performance.

As can be seen, tests are scored only as necessary to identify existing training needs.

Evaluating and Appraising—Objective testing is preferred to subjective evaluations and appraisals. Since most tests are unreliable in such KSA's as record keeping, public relations, supervision, and first-level management, evaluations and appraisals are obtained.

Evaluations are obtained from the immediate superior on those KSA's in which he feels confident about his knowledge of the individual. Self-appraisals are obtained in connection with those KSA's, particularly supervision and first-level management, in which the employee is himself the best judge of his training needs.

So that the evaluations and appraisals can be made as objectively as possible, the following steps are taken:

1. The participants are fully informed as to the objectives and the technology of the training needs survey.
2. The participants are fully informed as to the standard of training applicable to each KSA.
3. The participants are assured that the results will be held in confidence by the project staff. (All tests, evaluations and appraisals are identified by employee number. The employee identifications are separated from the survey materials to avoid the use of survey results in connection with such things as salary increases and promotions.)

The same scoring system is used for the evaluations and appraisals as is used for the tests:

> A score of 1 represents a high-priority training need.
> A score of 2 represents a low-priority training need.
> A score of 3 represents no training need.

TABLE 2

TYPICAL SUMMARY OF BASIC KSA TRAINING NEEDS TEST RESULTS AND PROJECTIONS OF STATEWIDE TRAINING NEEDS

Personnel Category	Persons Tested	In Need of Training					
		Dept.-Div.-District Orientation		Maintenance Function Orientation		Terminology and Nomenclature	
		Number	Percent	Number	Percent	Number	Percent
Supervisors							
Foreman IV	6	1		–		–	
Foreman III	12	2		2		1	
Foreman II	20	10		9		7	
Foreman I	32	22		19		17	
Group total	70	35	50	28	40	25	35
Potential Supervisors							
Equipment operator IV	8	6		4		3	
Equipment operator III	12	9		6		5	
Maintenance man II	50	42		28		22	
Mechanic III	10	7		6		6	
Group total	80	64	80	44	55	36	45
Statewide Forces	Persons Represented			Projected Results			
Supervisors	200	100		80		70	
Potential supervisors	800	640		440		360	

Note: Only scores of 1 (representing high-priority training needs) were used.

Tabulating and Projecting Results—The results obtained from the sample employee groups are tabulated and projected to represent the results that would be obtained if the total force were tested, evaluated, and appraised.

Table 2 contains a summary of the results typically obtained when samples of current and potential maintenance supervisors are tested in connection with selected basic KSA's.

Table 3 contains typical summaries of training needs attributable to the specialized KSA's.

Concerning advanced KSA's, typically 80 to 100 percent of the first-line managers indicate a need for training in the principles and practices of management. Also, they indicate a preference for training first in the technical phases of road and bridge maintenance and then in the supervisory and management phases of their work. Most persons in this group are knowledgeable about that which is represented by the basic KSA's.

TABLE 3

TYPICAL SUMMARY OF SPECIALIZED KSA TRAINING NEEDS TEST RESULTS AND PROJECTIONS OF STATEWIDE TRAINING NEEDS

Personnel Category	Total Force	Sample Group	Base Repairs		Gravel Road Repairs		Asphalt Surface Repairs	
			Tested	In Need	Tested	In Need	Tested	In Need
Supervisors								
Foreman IV	10	6	6	2	6	1	6	1
Foreman III	30	12	4	2	3	1	6	2
Foreman II	60	20	8	3	9	3	10	4
Foreman I	100	32	12	6	10	7	16	12
Group total	200	70	30	13	28	12	38	19
Potential Supervisors								
Equipment operator IV	40	8	6	3	5	2	7	5
Equipment operator III	80	12	6	4	6	4	8	6
Maintenance man II	620	50	20	14	24	16	35	29
Mechanic III	60	10	–	–	–	–	–	–
Group total	800	80	32	21	33	22	50	40
Statewide Forces					Projected Results			
Supervisors	200	70	85	35	80	35	110	55
Potential supervisors	800	80	320	215	328	220	500	400

Note: Projected figures have been rounded to the nearest 5.

Summary of Needs—The following list contains a typical training needs summary—for current maintenance supervisors—the needs attributable to many KSA's have been deleted for purposes of brevity:

Basic KSA Training Needs	Number of Persons	Percent of Force
1. In the objectives and programs of the Department, the Maintenance Division, and the assigned district	100	50
2. In the basic technology of road and bridge maintenance	80	40
3. In the terms used to represent road and bridge structural elements and road and bridge maintenance activities	70	35
4. In road and bridge maintenance standards	140	70
5. In the classification and use of soils and aggregates	125	62
6. In the classification and use of asphaltic materials	90	45
7. In the use of portland cement concrete	160	80
8. In the use and capacities of highway maintenance equipment	120	60
9. In basic mathematics	115	57
10. In the calculation of areas and volumes applicable to maintenance work	135	67
11. In keeping records	135	67
12. In using reference manuals	85	42
Specialized and Advanced KSA Training Needs		
13. In base repair supervision	35	
14. In gravel road repair supervision	35	
15. In asphalt surface repair supervision	55	
16. In portland cement structure repair supervision	60	
17. In drainage maintenance supervision	85	
18. In right-of-way maintenance supervision	80	
19. In shoulder maintenance supervision	70	
20. In sign, signal, and markings maintenance	10	
21. In the principal practices of supervision	170	
22. In the basic principles of first-line management	10	

Analysis of the list indicates that the training needs attributable to any given KSA can be identified and, to a certain extent, quantified for analysis purposes and the training needs may range from only a few persons on one KSA to nearly the total force on another.

The following list contains a typical summary of the training needs attributable to potential maintenance supervisors who are drawn from the ranks of the equipment operators and mechanics. Percentages given are for persons who will actually be promoted to supervisory positions, as against percentages of the current force.

Basic KSA Training Needs	Percent in Need
1. In the objectives and programs of the Department, the Maintenance Division, and the assigned District	80
2. In the basic technology of road and bridge maintenance	55
3. In the terms used to represent road and bridge structural elements and road and bridge maintenance activities	45
4. In road and bridge maintenance standards	90
5. In the classification and use of soils and aggregates	85
6. In the classification and use of asphaltic materials	60

Basic KSA Training Needs (continued)	Percent in Need
7. In the use of portland cement concrete	80
8. In the functions and capacities of highway maintenance equipment	70
9. In basic mathematics	60
10. In the calculation of areas and volumes applicable to maintenance work	70
11. In keeping records	90
12. In using reference manuals	90

Most of these persons will need training in the basic KSA's. Perhaps the highest priority of need can be attributed to the use of reference manuals, the keeping of records, and the application of standards, but significant needs exist in relation to all basic KSA's.

A summary of typical training needs attributable to the specialized KSA's is not shown. As would be expected, almost all potential supervisors are in need of training relative to the specialized KSA's that will apply to their work assignments.

Summary of the Needs Identification Procedure

The principal steps involved in identifying the training needs of an employee force are summarized as follows:

1. Appoint a training needs committee and a project staff to carry out the survey. The members of the committee should be knowledgeable about one or more activities carried out by the maintenance supervisors; those on the project staff should be knowledgeable about training.
2. Identify every activity (job element) carried out by the maintenance supervisors, and the principal tasks performed in connection with each activity.
3. Identify the combinations of knowledge, skills, and abilities needed to perform each task (KSA's).
4. Develop highly work-related performance and written tests in connection with each combination of knowledge, skills, and abilities—except those for which testing is an unreliable method of identifying training needs. Supervisory, public relations, and management abilities are not easily measured by performance or written tests.
5. Develop evaluation and self-appraisal procedures for use in obtaining indications of the training needs attributable to such things as supervision, public relations, and management.
6. Select individuals at random from the forces of maintenance supervisors and potential supervisors, and use the tests, evaluations, and appraisals to obtain indications of their training needs.
7. Tabulate and project the training needs of the samples to represent the training needs of all maintenance supervisors and potential supervisors.

EMPLOYEE CHARACTERISTICS IDENTIFICATION PROCEDURE

The identified training needs of an employee force are one set of the principal data needed for planning an overall training program. The other data needed are those that reflect the characteristics and attitudes of the persons to be trained.

Among the characteristics that have bearing on the design of training programs are (a) the age, education, and experience distributions of the employees, (b) the relative capacities of the individuals to absorb training, (c) the prevailing attitudes of the employees toward training, and (d) the geographical locations of the employees. The final characteristics that influence the design of the training materials are the turnover and force expansion rates.

Age, Education, and Experience Characteristics

Age Distribution—The distribution of the simulated training population according to age is given in Table 4.

TABLE 4

A TYPICAL DISTRIBUTION OF MAINTENANCE SUPERVISORS AND POTENTIAL SUPERVISORS ACCORDING TO AGE

Personnel Category	Persons Employed	Years of Age					
		Less than 25 Years	25 to 34 Years	35 to 44 Years	45 to 54 Years	55 to 64 Years	65 Years and Over
Supervisors							
Foreman IV	10	–	–	2	2	5	1
Foreman III	30	–	2	5	12	10	1
Foreman II	60	4	8	16	20	10	2
Foreman I	100	11	9	24	34	17	5
Group total	200	15	19	47	68	42	9
Percent of group	100	7.5	9.5	23.5	34	21	4.5
Average age, weighted	47 years						
Potential Supervisors							
Equipment operator IV	40	–	2	11	12	14	1
Equipment operator III	80	1	7	24	30	18	–
Maintenance man II	620	61	59	150	216	111	13
Mechanic III	60	1	4	17	21	16	1
Group total	800	63	82	202	279	159	15
Percent of group	100	8	10	25	35	20	2
Average age, weighted	45 years						

Education Distribution—The distribution of the simulated training population according to education is given in Table 5.

Experience Distribution—The distribution of the simulated training population according to years of experience with the Department of Highways is given in Table 6.

Capacity-to-Learn Characteristics

New training techniques have been developed which have successfully extended training to persons previously considered to be incapable of taking training. But limitations still exist with regard to the training of some individuals. Some specialists in training insist that even these can be trained, but the costs of training exceed the values to be obtained. In view of this, relationships have been established between individual capacities to learn and the training that will be provided to those individuals.

TABLE 5

A TYPICAL DISTRIBUTION OF MAINTENANCE SUPERVISORS AND POTENTIAL SUPERVISORS ACCORDING TO EDUCATION

Personnel Category	Persons Employed	Years of Education						
		0 to 4 Years	5 to 7 Years	8 Years	9 to 11 Years	12 Years	13 to 15 Years	16 Years
Supervisors								
Foreman IV	10	–	2	1	3	4	–	–
Foreman III	30	–	7	3	5	12	–	3
Foreman II	60	4	7	7	16	20	5	1
Foreman II	100	8	16	17	20	26	11	1
Group total	200	12	32	28	44	62	16	6
Percent of group	100	6	16	14	22	31	8	3
Average education level, weighted	9.7 years							
Potential Supervisors								
Equipment operator IV	40	7	9	14	8	2	–	–
Equipment operator III	80	12	16	29	18	5	–	–
Maintenance man II	620	103	87	103	119	207	1	–
Mechanic III	60	6	8	30	15	1	–	–
Group total	800	128	120	176	160	215	1	–
Percent of group	100	16	15	22	20	27	–	–
Average education level, weighted	8.2 years							

TABLE 6

A TYPICAL DISTRIBUTION OF MAINTENANCE SUPERVISORS AND POTENTIAL SUPERVISORS ACCORDING TO EXPERIENCE

Personnel Category	Persons Employed	Years of Experience					
		Less Than 1 Year	1 to 3 Years	4 to 6 Years	7 to 10 Years	11 to 19 Years	Over 20 Years
Supervisors							
Foreman IV	10	–	–	–	1	3	6
Foreman III	30	–	–	1	3	7	19
Foreman II	60	–	5	7	9	28	11
Foreman I	100	2	3	9	24	60	2
Group total	200	2	8	17	37	98	38
Percent of group	100	1	4	9	18	49	19
Average experience level, weighted	14 years						
Potential Supervisors							
Equipment operator IV-	40	–	–	2	13	14	11
Equipment operator III	80	1	12	18	27	22	–
Maintenance man II	620	54	131	111	104	212	8
Mechanic III	60	–	1	6	15	33	5
Group total	800	55	144	137	159	281	24
Percent of group	100	7	18	17	20	35	3
Average experience level, weighted	9 years						

The Wonderlic Personnel Test, developed by E. F. Wonderlic, Northfield, Ill., provides an indication of the relative capacities of individuals to learn from training. It is one of the tests most widely accepted and used by governments and industry because there is a high correlation between performance in the test situation and in the learning situation, and it has been validated with groups of actually employed persons.

Wonderlic Questions—The Wonderlic Personnel Test consists of 50 questions. Sample questions drawn from various forms of the test are shown in Figure 1. (Eight forms are available.)

The test indicates each person's relative capacity to work with words, numbers, clerical data, statements in logic, and simple problems in geometry. Questions proceed from the simple to the more complex, placing premium values on high scores. Each participant is given 12 minutes to answer as many questions as possible. The number of correct answers given is the participant's test score. The attainment of high scores obviously is dependent on unusual ability with words, numbers, logic, and spatial relationships.

The Wonderlic Personnel Test has limited value when used to measure the relative capacities of persons to learn if the individuals tested have had little formal education or have been educated in other than the English language. This test is used with maintenance personnel, but measures less dependent on reading ability are needed for some personnel.

Wonderlic Score Interpretations—Scores can be interpreted as follows, with special interpretations needed for those individuals who have had limited formal education or have language difficulties:

1. Scores of 1 to 6 indicate very limited capacities to learn. Persons with these scores can usually be taught to use hand tools.
2. Scores of 7 to 11 indicate capacities to learn equivalent to those needed by truck drivers, messengers, and supervisors of common laborers.
3. Scores of 12 to 17 indicate capacities to become equipment operators, mechanics, and day-to-day supervisors of single maintenance crews.
4. Scores of 18 and above indicate capacities to become highly skilled equipment operators and mechanics, and supervisors of two or more maintenance activities.
5. Scores of 24 and above indicate capacities to learn the planning, scheduling, and controlling functions well enough to direct a large road and bridge maintenance force.
6. Scores of 30 and above indicate capacities to learn the principles of management.

In the following set of words, which word is different from the others?
1 cinnamon, 2 ginger, 3 clove, 4 tobacco, 5 mint ..... [___]

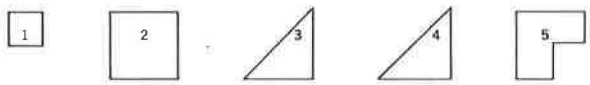
How many of the five items listed below are exact duplicates of each other? ..... [___]

Patterson, A. J.	Paterson, A. J.
Smith, A. O.	Smith, O. A.
Bleed, O. M.	Bleed, O. M.
Petersen, O. W.	Peterson, O. W.
Cash, I. O.	Cash, I. O.

Assume the first 2 statements are true. Is the final one: (1)true, (2)false, (3)not certain?
Fred greeted Mary. Mary greeted Ned. Fred did not greet Ned. ..... [___]

A train travels 60 feet in 1/5 second. At this same speed, how many feet will it travel in 3 seconds? ..... [___]

Three of the following 5 parts can be fitted together in such a way to make a triangle. Which 3 are they? ..... [___]



A dealer bought some cars for $2500. He sold them for $2900, making $50 on each car. How many cars were involved? ..... [___]

Figure 1. Typical questions selected from the Wonderlic Personnel Test.

These values must be used with discretion. Capacity to learn is affected by motivation and willingness to learn. Persons who score in the 12 to 17 range may be as trainable as those scoring in the 24 to 29 range, because of unusual personal drive. In contrast, persons who score in the 24 to 29 range may be only as trainable as those who score in the 12 to 17 range, because of lack of interest.

Typical Wonderlic Test Results—The distribution of the simulated training population according to their Wonderlic scores is given in Table 7.

TABLE 7

A TYPICAL DISTRIBUTION OF WONDERLIC PERSONNEL TEST SCORES

Personnel Category	Persons Employed[a]	Scores 1 to 6	Scores 7 to 11	Scores 12 to 17	Scores 18 to 23	Scores 24 to 29	Scores 30 and above
Supervisors							
Foreman IV	10	—	—	—	2	7	1
Foreman III	30	—	1	5	11	11	2
Foreman II	60	—	2	9	19	26	4
Foreman I	100	—	5	19	39	31	6
Group total	200	0	8	33	71	75	13
Percent of group	100	0	4	17	35	37	7
Potential Supervisors							
Equipment operator IV	40	—	—	2	24	12	2
Equipment operator III	80	1	2	21	39	15	2
Maintenance man II	620	23	52	107	167	240	31
Mechanic III	60	—	1	23	18	14	4
Group total	800	24	55	153	248	281	39
Percent of group	100	3	7	19	31	35	5

[a]Distributions in this table imply that all personnel in a training population are tested. Actually, only a sample needs to be tested to obtain indications for the total force.

The data in Table 7 indicate the following:

1. Four percent of the current supervisors achieved scores of 7 to 11, indicating limited capacities to learn the technology of maintenance, or the need for paying special attention to a language or reading problem in developing training materials.
2. Seventeen percent of the supervisors attained scores of 12 to 17, indicating potential to learn those things necessary to becoming equipment operators and mechanics, or providing day-to-day supervision to single crews.
3. Thirty-five percent of the supervisors achieved scores of 18 to 23, and 37 percent achieved scores of 24 to 29, indicating ample capacities to learn to supervise several crews and to do the planning, scheduling, and controlling necessary for an extensive maintenance program.
4. Seven percent of the supervisors achieved scores of 30 and above, indicating management potential.
5. Ten percent of the potential supervisors probably would have difficulty taking technical training of any kind, and 19 percent probably should, at best, be limited to small gang supervision.
6. Seventy-one percent of the potential supervisors achieved scores of 18 and above—a number sufficient to provide the maintenance supervisors needed to fill all foreseeable future vacancies.

Training Approach Characteristics

Several other characteristics of the employee force determine many of the characteristics of the final training program. Among these are the attitudes of the employees toward training and their opportunities to take training, the locations of the persons to be trained, and the numbers of persons that will be in need of the same training in the foreseeable future.

Attitudes and Opportunities—Questionnaires and interviews have revealed the following attitude and opportunity-for-training characteristics of maintenance supervisors:

1. They prefer individual or small group training, usually because they have been away from classroom instruction for many years.
2. They can be expected to accomplish little through home study, because few of them have the necessary privacy.
3. They can be expected to accomplish little through the normal correspondence school and adult education channels, because they have difficulty translating concepts and practices that apply to industrial situations into situations that occur in the maintenance function.
4. They can be expected to pay little, if any, of the cost of training, because their incomes are usually committed to other things.
5. They will be highly receptive to training, particularly if the training is highly job-related and specific and if it is presented in terms they can understand.
6. They have ample opportunity to take training during regular working hours, if the training is designed to permit individuals to train themselves or to train in small groups, and if training can be interrupted from time to time for the performance of work.

Locations—Highway departments have shops and stations located throughout their respective states, provinces, counties, and cities. Maintenance supervisors also are dispersed geographically, sometimes to more than one hundred locations.

Expansion—Actual data have not been collected to document the rates of expansion of the maintenance supervisor forces in different highway departments. Nevertheless, it is clear that two types of expansion are taking place: an expansion of the duties and responsibilities delegated to individual supervisors as the maintenance workload is increased, and expansion of the numbers of supervisors employed.

Turnover—Typical turnover rates among the maintenance supervisors run from 6 percent to 15 percent or more of the total force. The numbers of new supervisors needed as replacements exceed these rates slightly, to provide for a few persons who are advanced temporarily.

Summary of the Characteristics Identification Procedure

The following characteristics of a maintenance supervisor force influence the characteristics of the final training program:

1. Age, education, and experience distributions,
2. Capacity to absorb training,
3. Attitudes toward training and opportunities to take training,
4. Geographical distribution, and
5. Rate of expansion and of turnover.

Data relative to these characteristics are obtained from the personnel records, from tests, questionnaires, and interviews.

TRAINING PROGRAM PLANNING PROCEDURE

The objective of training is the development in the supervisors of the performance capabilities needed to do the work. The development of a plan for training involves (a) summarizations of the data that have bearing on the training problem, (b) analysis and interpretation of the summarized data, and (c) preparation of a framework of policies, specifications, and organizational relationships for training.

Summary of Collected Data

The data collected relative to the training needs and the training-related characteristics typical of maintenance supervisors are summarized below, together with data relative to future training needs.

Summary of Training Needs—The training needs of the maintenance supervisors can be summarized briefly as follows:

1. Maintenance supervisors, as a group, have responsibility for 25 or more major work activities, and have need for 50 or more combinations of knowledge, skills, and abilities.
2. Maintenance supervisors, individually, have need for 23 combinations of basic knowledge, skills, and abilities and at least one (but sometimes 10 or more) combination of specialized knowledge, skills, and abilities.
3. Current maintenance supervisors typically have need for training in the basic and the specialized knowledge, skills, and abilities, with special reference to the standards applicable to the maintenance function, and the materials, equipment, and methods used in road and bridge maintenance.

Summary of Characteristics—The maintenance supervisor characteristics that have significance in relation to the training effort are summarized as follows:

1. Persons to be trained range in age from less than 25 to more than 65 years; in education, from less than 4 to as many as 16 years; and in maintenance experience, from less than 1 to more than 20 years.
2. They range in learning capacity from that needed to become useful on the simplest types of labor to that needed for advanced management responsibilities.
3. For the most part, they are (a) apprehensive about classroom and large-group training, (b) unable to take training at home or after working hours, (c) unable to pay the costs of training, (d) unable to relate available correspondence school and adult education courses to the maintenance function, and (e) very willing to take training if it is highly job-related and is directed at their specific training needs.
4. They are dispersed throughout a sizable geographical area.
5. They have ample opportunity to take training during regular working hours, if the training materials are designed for individual or small-group self-training, and if the training can be interrupted as necessary for the performance of work.

Summary of Future Needs—Indications of the future training needs attributable to the maintenance supervisor force can be summarized as follows:

1. There consistently will be need to retrain individuals to restore capabilities lost through periods of disuse.
2. Revision of training materials to reflect changes in standards, materials, equipment, and methods will be necessary.
3. There will be need to expand the performance capabilities of many current supervisors.
4. It will be necessary to train new supervisors to fill new positions and to fill positions vacated through turnover—this may represent 8 to 15 percent of the current training needs.
5. The persons to be advanced are reasonably identical to the current supervisors in terms of age, education, maintenance experience, capacities to absorb training, and attitudes toward training.
6. The persons to be advanced are less knowledgeable about maintenance work and less able, without further training, to supervise maintenance work than are the current supervisors.

Analysis of Data

Training Needs Data—The training needs data indicate that (a) technician-supervisors are needed for the maintenance function and (b) a program of training that encompasses all of the knowledge, skills, and abilities needed by maintenance supervisors should be developed.

Technican Supervisors—The existence of 25 or more major maintenance activities and 50 or more combinations of knowledge, skills, and abilities indicates that the maintenance function is highly diversified and technical. Maintenance supervisors have need to be technically trained. In addition, they have need to be effective supervisors, with special reference to the effective utilization of manpower, equipment, and materials.

Total Program—None of the 50 combinations of knowledge, skills, and abilities can be omitted. Some combinations are of a higher priority than others, but the development of fully qualified technician supervisors is dependent on the development of a training program that includes all of the subject matter represented by the 50 KSA's.

Employee Characteristics Data—The employee characteristics data indicate that special care must be taken in the development of the training courses and materials. The characteristics that dictate special care are the age, education, and experience variations, the learning capability variations, the attitudes toward training, and the opportunities for training. Consideration must also be given to the geographical dispersion of the personnel.

Age, Education, Experience—Obviously, persons less than 25 years old have an advantage over persons 50 to 65 years of age in the classroom. Attempts to treat them alike usually will fail. It seems best to design much of the training (at least in the early stages) so that these persons can be trained individually or in small, compatible groups.

Just as obviously, persons who cannot read and write cannot successfully be grouped with high school and college graduates for training purposes. It is almost as difficult to work with persons ranging from four years to ten years in education. It is necessary to (a) provide for individual training where feasible and small group training where necessary, (b) use terms and words common to the group and carefully define any new terms, and (c) organize the subject matter in increments appropriate to the persons to be trained.

The variations in maintenance experience are important from a motivation standpoint. Individuals with long experience have difficulty taking training together with individuals with limited experience. In addition, experienced personnel have difficulty in accepting new concepts. The variations in experience can best be overcome by providing individual and compatible small-group training and by insuring that the subject matter is fresh, complete in details, consistent, practical, and workable.

Learning Capability—Just as persons with vastly different age, education and experience characteristics should be treated separately in the training situation, persons with vastly different learning capabilities should be treated separately. Some current maintenance supervisors and some potential maintenance supervisors should not be

trained. Typically, 25 to 35 percent of the supervisors who need training, and upwards of 35 percent of the potential supervisors who need training, can benefit very little from training.

Most current maintenance supervisors and more than an adequate number of potential supervisors can readily be trained. To overcome the differences that exist in their learning capabilities, they should be trained individually, or in small, compatible groups. Individual and small-group training permit maximum concentration on the segments of training that give difficulty, and self-pacing avoids leaving the slow learners behind and the fast learners bored.

Attitudes and Opportunities—The considerations that must be given to the employee attitudes toward training and the employee opportunities for training are as follows:

1. Training should be accomplished during regular working hours and, insofar as possible, at the regular places of work.
2. Training costs should be paid by the employer.
3. Training should be specific in relation to the training need. People who take training in areas in which they are already knowledgeable are usually adversely affected when taking needed training.
4. Training should be appropriate as to time. Training that greatly precedes the need is less effective than training provided just in advance of need. Training that follows the need is of little value.
5. Training should be highly job-related.
6. Training should, insofar as possible, be self-pacing and should permit self-scheduling.

Locations—The geographical dispersion of the persons to be trained causes two problems: scheduling and providing for uniformity. As to scheduling, classroom training is difficult to arrange when the persons involved have supervisory responsibilities. With regard to uniformity, it is clear that the best results are obtained if the subject matter of training is identical from trainee to trainee, location to location, and year to year. This cannot be achieved, more than in part, if instructors are used. From a training standpoint, it seems best to develop self-instructional materials and self-operating workshops.

Future Needs Data—The data relative to future training indicate the following considerations:

1. The training courses and materials should be designed so that changes can be made in the subject matter as changes occur in the technology of maintenance and subject matter that remains stable for several years can be developed once and used as long as it is satisfactory.
2. The same training needs continue to occur year after year, although in reduced amounts, indicating that permanent training materials should be developed insofar as possible.
3. The total training effort needed is large, but manageable.

Development of Framework for Training

The framework for training includes the policies, program specifications, and training organization.

Policies for Training—The data analyses and interpretations provide the policies for training:

1. Training is recognized as a permanent and integral part of the total maintenance workload.
2. Training shall be accomplished during regular working hours at no out-of-pocket cost to the employees.
3. Training shall be administered by the operating organization.
4. Training shall be specific as to the subject matter needed and appropriate as to the time of need. Individuals shall be required to take only that training which provides the knowledge, skills, and abilities required for the performance of assigned work.

5. The training materials shall be revised as necessary to incorporate changes in maintenance technology.

Specifications for Training—The specifications for training are taken from the training needs and employee characteristics data, and from the policies for training:

1. Each course of training shall include the subject matter representing the training needed by a significant number of maintenance supervisors, but shall be so limited that few supervisors will be required to take training in one subject matter area in order to obtain training in another.
2. The subject matter of each course shall be limited to that needed for satisfactory work performance, shall include all that is needed, and shall be set forth in terms and examples taken from the work situation.
3. The courses of training shall be organized in series, so that prerequisite courses are identified clearly, and so that individuals can develop their performance capabilities in a logical sequence.
4. Individual self-instruction techniques shall be given first preference in the selection of presentation methods, followed successively by small-group self-instruction, monitored small-group instruction, and classroom instruction.
5. Training materials and self-operating workshops shall be made available at the locations nearest to the personnel to be trained, subject to considerations of costs.

Organization for Training—The maintenance supervisor training organization should consist of subject matter experts, training specialists, and the operating managers.

Subject Matter Experts—A committee of persons thoroughly knowledgeable about the maintenance of roads and bridges should be established. The function of this committee is outlined as follows:

- To provide guidance and assistance to the training personnel responsible for the collection of subject matter by indicating work under way that can be studied, persons who can be questioned, and samples, diagrams, and models that can be obtained.
- To review subject matter that has been "shaped-up" by the data collection personnel before it is incorporated into training materials.
- To conduct field research and field testing as necessary to fill in gaps in the subject matter.
- To develop standards for the maintenance function where none exist and to improve existing standards, or to submit standards problems to a research organization for solution.
- To approve the subject matter included in training materials.
- To indicate changes that should be made in existing training materials.

Training Specialists—The training specialists should include a subject matter expert, two data collectors, and one or two training specialists.

The subject matter expert should be an engineer from the maintenance organization, or someone professionally trained who can assimilate maintenance technology quickly. This person should plan the data collection; review the collected data to insure that it is reasonably complete, consistent, and practical; conduct research to fill in gaps in the data; and recommend additional research as necessary. He should assist the subject matter committee on all review and development work, and be available to the writers while the final training materials are being developed.

The data collectors should work with the operating maintenance supervisors to obtain the subject matter for training. They should observe work under way, interview operators and supervisors, collect samples, take pictures, develop diagrams, and do those things necessary to record data about maintenance technology. They should also check the collected information against the specifications, directives, manuals, and other references available from the central maintenance organization.

The training specialists should be knowledgeable about the principles of learning and the technology of training. They should be skilled in organization of subject matter for training, in developing training materials (including visual and audio materials), and in validating, editing, and preparing materials for duplication.

Operating Managers—The operating managers should be responsible for implementing the training program.

To summarize the planning procedure, the development of a plan for training involves itemizing the data relative to training needs and trainee population characteristics, analyzing and interpreting those data, and preparing a framework of policies, specifications, and organization relationships for training.

SUMMARY OF PAPER

The objective of this paper is to set forth a technique that can be used to identify the training needs of maintenance supervisors and to develop a plan for the training of those supervisors. Seven principal steps are involved:

1. The work performed by the maintenance supervisors is identified.
2. The knowledge, skills, and abilities needed to perform the work are identified.
3. The extent to which currently employed maintenance supervisors need training in connection with the required knowledge, skills, and abilities is identified.
4. The extent to which personnel to be advanced to supervisory positions need training in connection with the required knowledge, skills, and abilities is identified.
5. The characteristics of the maintenance supervisors and potential supervisors are identified.
6. The work analysis, training needs, and employee characteristics data are analyzed and interpreted from a training standpoint.
7. The data, analyses, and interpretations are used to develop the framework of policies, specifications, and organization for training.

The conduct of a training needs survey can best be accomplished through the coordinated effort of persons thoroughly knowledgeable about the maintenance function and persons thoroughly knowledgeable about training.

Teaching Methods Employed in a Maintenance Personnel Training Program

IAN B. PACKMAN, Port of New York Authority

The Port Authority in-plant maintenance training program is described in a general way, with the electrical training program used as an illustration. Emphasis is placed on such factors as the role played by supervisors in curriculum development, the use of well-trained instructors and appropriate training materials, and the proper learning environment.

•THE Port Authority at the present time has a career staff of over 7,000 employees, carrying out its work on a self-supporting basis without cost to the taxpayer. With its vast network of facilities, it has a continuing need for maintenance employees of all skills and abilities.

To provide a well-trained and efficient staff for this exclusive operation, the Port Authority initiated its in-plant maintenance training program over 25 years ago, not only to train personnel, but also to provide employees with the skills necessary to do a better job in their present positions and to obtain promotion to more highly skilled jobs within the organization. Many men have risen to better paying jobs in the Port Authority as a result of the training program. The prime functions of training are to meet the requirements of the employer for skilled people and to provide the employee with a foundation of learning and skill acquirement for his own advancement.

Before discussing our in-plant training, I will attempt to describe one of the programs currently under way, the electrical apprentice training program. This is an all-around program for training maintenance personnel with little experience other than basic schooling to become qualified journeymen electricians. The program is as follows:

PROPOSED PROGRAM ELECTRICAL APPRENTICE TRAINING
Class and Shop Work Sections

	Section Time
Unit I—Basic Mathematics (72 hr)	
Section A—Whole Numbers	9 hr
Section B—Fractions	12 hr
Section C—Decimals	12 hr
Section D—Percentage	9 hr
Section E—Power and Roots	6 hr
Section F—Ratio and Proportion	6 hr
Section G—Simple Formulas	6 hr
Section H—Mensuration	6 hr
Section I—Triangles	6 hr

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	Section Time
Unit II—Basic Science (72 hr)	
Section A—Basic Principles—Science Matter, Measurement	6 hr
Section B—Mechanics and Machines	12 hr
Section C—Magnetism and Electrical Energy	12 hr
Section D—Heat Energy and Heat Machines	12 hr
Section E—Light Energy	6 hr
Section F—Sound Energy	6 hr
Section G—Electronics	12 hr
Section H—Nuclear Energy	6 hr
Unit III—Blueprint Reading and Sketching (72 hr)	
Section A—Preliminary Study of Plans	3 hr
Section B—Unit Substation and High-Voltage Metering Equipment	6 hr
Section C—Feeder Ducts and Distribution Transformers	6 hr
Section D—Panelboards and Sub-Feeders	6 hr
Section E—Lighting Circuits and Systems	6 hr
Section F—Feeder Duct and Plug-In Bus Duct System	6 hr
Section G—Motors and Controllers	6 hr
Section H—Precipitron Units	3 hr
Section I—Synchronous Condensers	6 hr
Section J—Three-Phase Trolley Ducts	3 hr
Section K—Signal Systems	6 hr
Section L—Ventilating, Air Conditioners	3 hr
Section M—Telephone Raceways	3 hr
Section N—Alternate Methods of Feeder Layout	6 hr
Unit IV—Electrical Theory and Circuits (72 hr)	
Section A—Electron Theory and Ohms Law	3 hr
Section B—Series Circuits	3 hr
Section C—Parallel Circuits	3 hr
Section D—Series-Parallel Circuits	3 hr
Section E—Electrical Energy and Power	6 hr
Section F—Batteries	3 hr
Section G—Electrical Conductors and Wire Sizes	3 hr
Section H—Voltage Loss on Conductors	6 hr
Section I—Magnets and Magnetic Fields	6 hr
Section J—Electromagnetism	6 hr
Section K—Generation of Electromotive Force	6 hr
Section L—Direct-Current Motor Principles	6 hr
Section M—Typical Bell Circuits	6 hr
Section N—Switch Control of Lighting Circuits	3 hr
Section O—Wiring Methods and Materials	3 hr
Section P—Remote-Control Systems for Lighting Circuits	6 hr
Unit V—Alternating Current (72 hr)	
Section A—Alternating Current—Principles	6 hr
Section B—Inductance and Inductive Reactance	6 hr
Section C—Capacitance and Capacitive Reactance	6 hr
Section D—Series, Circuit, Resistance, and Inductance	6 hr
Section E—Series, Circuit, Resistance, Inductance, and Capacitance	6 hr
Section F—A-C Parallel Circuits Containing Inductance	6 hr
Section G—A-C Parallel Circuits Containing Inductance, and Capacitance	6 hr
Section H—A-C Power, Power Factor, and Power Factor Connection	6 hr
Section I—Single-Phase Three-Wire Service Entrance	6 hr
Section J—Installation of a Single-Phase Three-Wire Service Entrance	6 hr
Section K—Installation of a Three-Phase Three-Wire Service Entrance	6 hr
Section L—Fluorescent Lighting	6 hr

	Section Time
Unit VI—D-C and A-C Theory—Applied (96 hr)	
D-C Section A—Operation Principles of D-C Generators	3 hr
Section B—The Separately Excited D-C Generator	3 hr
Section C—The Self-Excited Shunt Generator	3 hr
Section D—Compound Wound D-C Generator	3 hr
Section E—D-C Shunt Motor	3 hr
Section F—D-C Series Motor	3 hr
Section G—D-C Compound Motors	3 hr
Section H—Manual Starting Rheostats for D-C Motors	3 hr
Section I—Manual Speed Controllers	3 hr
Section J—Special Starting Rheostats and Controller	3 hr
Section K—Basic Principles of Automatic Motor Control	6 hr
Section L—The Counter-EMF Motor Controller	3 hr
Section M—The Voltage-Drop Acceleration Controller	3 hr
Section N—The Series-Lockout Relay Acceleration Controller	3 hr
Section O—Dynamic Braking With Motor-Reversed Control	3 hr
A-C Section P—Introduction to Polyphase Circuits	6 hr
Section Q—The Three-Phase Wye Connection	6 hr
Section R—The Three-Phase Delta Connection	6 hr
Section S—Basic Principles of Transformers	6 hr
Section T—Single-Phase Transformers	3 hr
Section U—The Single-Phase, Three-Wire Secondary System	6 hr
Section V—Single-Phase Transformers Connected in Delta	3 hr
Section W—Single-Phase Transformers Connected in Wye	3 hr
Section X—Wye and Delta Connections of Single-Phase Transformers	3 hr
Section Y—Instrument Transformers	3 hr
Section Z—Code Requirements for Transformer Installations	3 hr
Unit VII—Advanced Electrical Theory—Circuits and Equipment (51 hr)	
Section A—Physical and Electrical Characteristics of Three-Phase Alternators	3 hr
Section B—Three-Phase Alternator Connections and Windings	3 hr
Section C—Parallel Operation of Three-Phase Alternators	3 hr
Section D—Wiring for Alternating Current Generators	3 hr
Section E—The Three-Phase Squirrel-Cage Induction Motors	3 hr
Section F—Starting Three-Phase Squirrel-Cage Induction Motors	3 hr
Section G—The Starting Compensator	3 hr
Section H—The Three-Phase Wound-Rotor Induction Motor	3 hr
Section I—Manual Speed Controllers for Wound-Rotor Induction Motors	3 hr
Section J—The Synchronous Motor	3 hr
Section K—Controllers for Three-Phase Motors	3 hr
Section L—Three-Phase Motor Installation	3 hr
Section M—Motor Maintenance	3 hr
Section N—Selayn Units	3 hr
Section O—Single-Phase Induction Motors	3 hr
Section P—Repulsion-Type Motor	3 hr
Section Q—A-C Series Motors	3 hr
Unit VIII—Industrial Electronic Controls (72 hr)	
Section A—Electronic Theory	18 hr
Section B—Component Parts, Induction Coils, Tubes, Condenser, Rectifiers, Transformers	12 hr
Section C—Amplifiers	6 hr
Section D—Power Packs	6 hr
Section E—Rectifier Circuits	3 hr
Section F—Push-Pull Circuits	3 hr

	Section Time
Unit VIII—Industrial Electronic Controls (72 hr)-Continued	
Section G—Transistors	3 hr
Section H—Public Address Systems	3 hr
Section I—Boiler Controls	3 hr
Section J—Electrostatic Filters	3 hr

ELECTRICAL TRAINING PROGRAM
Field Work

1. Motor Application and Maintenance
   a. Single-Phase Motors
   b. Three-Phase Motors
   c. D-C Motors
   d. Generators
2. Control Circuits
   a. Boiler Controls
   b. Refrigeration and Air-Conditioning Controls
   c. Runway and Taxiway Controls
   d. Ticket Dispensary—Tolls Equipment
   e. Parcoa Gates
   f. High-Tension Controls
   g. Fire Alarm and Fire Protection Equipment—Proprietary Equipment
   h. Motor Controls and Starters
   i. Emergency Feeders and Generators
   j. Supervisory Controls
   k. Traffic Signal Control
   l. Telephone Systems
   m. CO Analyzers
3. High-Tension
   a. Safety Principles
   b. Mechanism and Transfer Gear
   c. Feeders
   d. Rules and Regulations
   e. Splicing
   f. Runway and Taxiway Circuits
   g. Tools and Meters and Their Use
   h. Operation
   i. Regulators and Transformers
4. Lighting
   a. Cold Cathode
   b. Fluorescent
   c. Mercury Vapor
   d. Incandescent
   e. Germicidal Lamps
   f. Sodium Vapor
   g. Elfaka
5. Electronics
   a. Amplifiers
   b. Power Packs
   c. Rectifier Circuits
   d. Push-Pull Circuits
   e. Transistors
   f. Public Address Systems

g. Boiler Controls
h. Electrostatic Filters

6. Special Equipment
   a. 95-foot Hi-Range
   b. 38-foot Bucket Truck
   c. Interior Relamping Rig
   d. Tower Trucks
   e. Other Special Devices

7. Underground Distribution System
   a. Types of Manholes
   b. Manhole Safety
   c. Types of Duct Systems
   d. Manhole Safety Precautions
   e. Manhole Identification
   f. Method of Handling Cable in Underground Systems

8. Overhead Distribution System
   a. Method of Accessibility
   b. Types of Overhead Devices
   c. Safety Rules and Regulations

9. General Distribution System
   a. Circuit-Breakers and Fuses
   b. Types of Distribution Wiring
   c. Types of Wire
   d. Time Current Ratings of Equipment
   e. Relaying Devices (Emphasizing High-Tension)

Normal apprentice training classes consist of 12 to 15 students working as electrical trades helpers. A high school diploma is a requirement; however, an exception may be made for a man who has been an electrical trades helper for five years. These courses generally run from 60 to 180 sessions. Each session usually lasts three hours, and is held once or twice a week at the location where the greatest number of students are concentrated. All of the sessions are given off-shift and the men are not paid for attendance.

This method of in-plant training is highly dependent on an adequate and dedicated staff and the organization of that staff. The instructors are chosen on the basis of their experience, trade skill, proficiency, and teaching ability, plus their background in administration. Our supervisory personnel develop a standard curriculum for each course in their special areas and are responsible for the day-to-day operation of the program. Attendance at an instructor-training seminar is required before one can qualify as an instructor. Many of these instructors have state licenses as qualified teachers.

In addition to electrical apprentice training, training programs include courses ranging from maintenance and clerical skills to supervisory and management development. There is an education refund plan through which employees who successfully complete courses relating to the work of the Authority receive total repayment of tuition fees. Since 1946, several thousand men have risen to better-paying jobs in the Port Authority through our training programs.

The result of adequate in-plant training to the Port Authority has been a more efficient and capable maintenance team. At the same time, in-plant training provides the individual employee with the opportunity to obtain the necessary skills for job advancement and to improve his standard of living. The resulting increased purchasing power is a direct aid to the general economy of the Port of New York communities.

Development of effective training materials, curriculums, and training aids are important to success. We have developed an overall writing guide beginning with our instructor-training course and ranging through all of the skills area. These curriculums are updated frequently and are kept abreast of Port Authority standards and standards of the various trade fields. Standard texts from the fields are used

where necessary. The teaching guide establishes the content of material, and suggests teaching aids, texts, and time allotments for each lesson. Recommended methodology is also included in each teaching guide. A handbook, entitled "Instructors Handbook for the Organization and Administration of an Instruction Program," has been developed within the skills training program and is an established guide to all of our training courses.

The first consideration in any program must be the trainee. The type of student, his age, and his ability must be the concern of the administration and the instructor. Adults are good students when properly motivated and are quite conscious of time invested in learning. They do not appreciate traditional methods of discipline. When their effects are rewarded, however, adults will display pride in their accomplishments. Pride is a reflection of morale and morale is one of the results of training.

Enthusiasm is contagious, expertness is respected, and sincerity is appreciated in the training situation. Successful instructors and supervisors exemplify the traits they want to instill in their students. Instructors themselves should be apt and willing learners. Because they represent the organization, they reflect the caliber of the organization. It is essential, therefore, that they exemplify the best in teaching, organization, management, and administration.

Instructors should see the overall picture of the training program so they can more intelligently understand their part in it. There should be communication between the people concerned with supervising and those instructing. Instructors should use training films, instructional aids, and demonstrations, and there should be application of newly learned skills. Group instruction should be followed by individual instruction when and wherever possible.

Students in maintenance skills training programs should be expected to participate in class discussions, take notes, and perform trade skills. Learning of operational skills should be followed by practical application on the job. If the training session includes a study period, the instructor should help trainees organize study time. He can help individual trainees when they experience difficulties. Some of the most valuable learning experience for trainees will take place in the shop or laboratory. Most valuable of all, of course, is full-time training followed by on-the-job training when possible. Shop and laboratory training are substitutes for on-the-job training. Regardless of site, the importance of shop experience is of extreme value because the trainee will be trying out the new skill in a safe, supervised environment. Programs involving the use of tools, equipment, and material need careful planning. Any shop or practical skills program will present a housekeeping problem and, therefore, a safety problem. Proper housekeeping and safety go hand in hand and are of extreme importance.

Supplementing any training program with an adequate library facility is a necessity. The instructor cannot teach everything, and the trainee cannot learn everything in the confines of a classroom or shop. Reference material should be made available to the trainee, instructor, and administrative staff.

In addition to skills-training, it is prudent to consider the academic advancement of the trainees in two areas—functional English and mathematics. Many employees cannot improve their skills ability because of the lack of formal academic training in these two areas. A carpenter who cannot subdivide a ruler or a plumber who cannot read a blueprint certainly cannot operate effectively in his skills area. In conjunction with skills training, classwork in related English and mathematics should be offered. This may be mandatory in some areas, but in other areas it may simply be considered desirable. Wherever possible, these courses should be under the direct supervision of the in-plant training administration so that the greatest possible benefit can be obtained. Close cooperation must be maintained between the skills-training instructors so that the related courses will be of most benefit to the trainee. This also benefits the trade instructor, who can then concentrate on technical skills training.

Appraising Results Derived from a Maintenance Training Program

A. P. CUNLIFFE, Department of Highways, Ontario

•THE quantity of salt used by the Department of Highways, Ontario, for snow and ice control increased from 1956 to 1966 by an average of 11 percent annually. The quantity of treated sand used during the same period increased by 4.3 percent annually. Since the highway mileage serviced by the Department has been increasing annually by an average of 2.3 percent, it is evident that the increased use of salt is only partly due to the increased mileage. It is generally believed that the increased use of deicing materials has resulted in an improved level of service on highways throughout the Province.

The Department's organization for winter maintenance is shown in Figure 1. There are 18 districts. In each district there are approximately four patrol supervisors reporting to the maintenance supervisor, five patrolmen (front line supervisors) reporting to each patrol supervisor, and twelve winter maintenance employees (snowplow operators, etc.) directed by each patrolman or his counterpart night patrolman on the second and third work shifts. Most of the salt and treated sand used for snow and ice control is spread by hired truckers using Department spreaders mounted on their trucks. These personnel also work under the direction of the patrolman or his counterpart.

Late in the winter of 1965-66 a Province-wide survey was conducted during a major snowstorm and each district was required to submit data pertaining to salt usage during and immediately after the storm, i.e., quantity of salt used, number of applications, and total mileage treated. This information was correlated and it was found that the rate of application varied between 300 and 1200 lb per 2-lane mile. This divergence occurred not only among districts but also among characteristically similar patrols in the same district. There was evidence that poor control of the rate and frequency of application were prime factors in the increased use of salt for snow and ice control.

Inasmuch as the annual bill for bulk salt had reached $4 million by 1966, it was obvious from the survey that effective control at the operations level, of the rate and frequency of application, would result in considerable savings. Accordingly, prior to the 1966-67 winter maintenance season, a uniform application rate was prescribed and all districts were instructed to calibrate their hydraulic spreaders to spread salt at this rate—450 lb per 2-lane mile. A truck speed of 20 mph was used in calibration. Simultaneously, a training program on the use of salt for snow and ice control was developed and presented in each district.

In 1965 the Department had retained the consulting firm of Roy Jorgensen and Associates to direct a research project to study its maintenance function. From this research a maintenance training group was organized to develop training materials aimed at field personnel. The first training program developed, "The Use of Salt for Snow and Ice Control," was conducted in the fall of 1966 and evaluated the following spring. This paper describes the manner in which this training program was developed and administered, and the conclusions drawn from its evaluation.

THE TRAINING PROGRAM

It was suggested that an approach be adopted similar to the one effectively used by the Virginia Department of Highways in their program on snow and ice control. Initially,

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it was necessary to determine the content and scope of the training program. Accordingly, a training committee was formed consisting of a district engineer, two district maintenance engineers, and two maintenance supervisors, all with considerable experience in maintenance operations. It was determined that the program, should cover the following five main subject areas:

1. Why salt is used for snow and ice control,
2. When it should be used,
3. How much should be used,
4. Where it should be placed on the road, and
5. How it should be placed there.

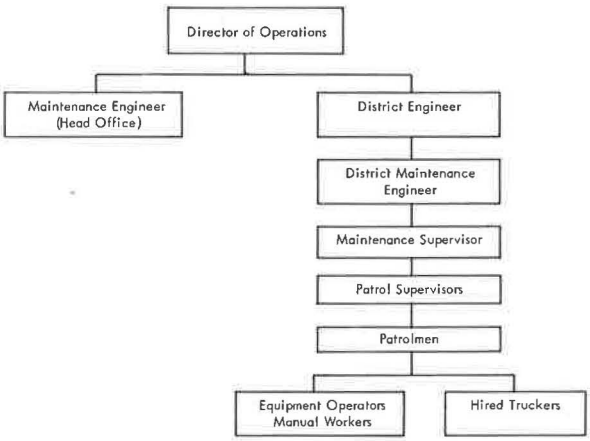

Figure 1. Winter maintenance organization.

The next decision was who should be trained. It was determined arbitrarily that the training should be directed toward the following two groups: all field staff required to make decisions pertaining to winter maintenance operations, i.e., patrolmen and night patrolmen; and all hired truckers. Finally, decisions were necessary concerning the form the training program should take, and how and by whom it should be conducted. It was decided that—

1. The major part of the program was to consist of an illustrated training aid in the form of a flip chart, 24 by 18 in. in size.
2. The chart was to be prepared for district maintenance engineers and maintenance supervisors to use as a focal point of discussion at meetings attended by patrol supervisors and patrolmen.
3. The flip chart was to be issued to all patrolmen so that they could train their night patrolmen and hired truckers.

Implementation

The flip chart was presented to the district maintenance engineers and maintenance supervisors at meetings held in each of the five Province regions to demonstrate its use as a training aid. Each district maintenance engineer was instructed to use the flip chart to train patrol supervisors and patrolmen; the patrolmen then trained their subordinate staff.

Preliminary Evaluation

At the midpoint of the winter maintenance season a preliminary evaluation of the training program was made and each district was asked the following questions:

1. How many meetings were held at which the flip chart was used as a training aid by the district maintenance engineer or maintenance supervisor?
2. What were the minimum and maximum number of people in attendance at meetings?
3. How many people received this training firsthand?
4. Approximately how many patrol supervisors, patrolmen, equipment operators, manual workers, and hired truckers attended each meeting?
5. How do you rate the flip chart as a training aid? Did it afford any real assistance in making your presentation?
6. How did your staff react to this training program? To what degree did they exhibit interest or indifference?

TABLE 1

SUMMARY OF INFORMATION PERTAINING TO TRAINING MEETINGS HELD IN EACH DISTRICT DURING FALL 1966

District	Total No. of Employees	Number of Meetings Held	Size of Meetings	Total Employees in Attendance	Classification of Those in Attendance						
					Patrol Supvrs.	Patrolmen	Night Patrolmen	Equipment Operators	Manual Workers	Hired Truckers	Others
1	197	3	14 to 21	50	3	19		5			
2	286	17	10 to 27	255		18		129	45	63	
3	397	14	10 to 36	321	5	25		219	24	42	6
4	554	11	8 to 50	278		←106→				72	102
5	341	17	6 to 20	175-200		*	*	*		*	
6	467	NA	NA	NA							
7	351	3	25 to 30	82	3	17		58		4	
8	412	2	5 to 10	15	1	3	10	1			
9	301	9	14 to 32	185	4	26	88		22	17	
10	178	1	21	21	3	18					
11	217	7	5 to 18	94	4	15	18	32		25	
13	189	6	12 to 16	80	2	18	48			6	6
14	218	12	9 to 28	230	3	13		90	112	12	
16	127	4	9 to 28	62	2	9		34	5	5	7
17	289	2	27 to 44	71	4	16		36		15	
18	283	10	4 to 12	61	5	13		39		7	
19	232	13	7 to 27	171	3	21		77	58	12	
20	167	5	3 to 11	30	5	19	3				3

*Numbers not available.

A summary of the replies to questions 1, 2, 3, and 4 is given in Table 1. It is apparent that while some district maintenance engineers left the training of patrol staff and hired truckers to their respective patrolmen, others trained considerable numbers of equipment operators, manual workers and hired truckers themselves. Responses to questions 5 and 6 indicate that the majority of district maintenance engineers and maintenance supervisors found the flip chart to be of considerable assistance in stimulating active discussion and maintaining interest at training sessions.

THE POST-TRAINING TEST

Toward the end of the winter maintenance season a post-training test (see Appendix) was given to a representative sample of field personnel to ascertain the current level of knowledge and to evaluate the training program, particularly the training aid. The post-training test was designed to cover almost the entire content of the illustrated training aid. A variety of techniques were used, e.g., true or false, multiple choice, and written answer, and in several cases questions were formulated so that the correct answer could come only from the training aid.

Implementation

All districts were instructed to test three people on each patrol who were using salt for snow and ice control, the patrolman, a night patrolman, and a hired trucker. The tests were given without forewarning and under supervision and only to those who had been exposed to the training program. To minimize "examination jitters" the testee was asked only to state his classification on the test paper—not his name.

When the testee handed in his test paper he was given a facsimile with correct answers, so that he could assess his own performance. It was believed that this would reinforce him in subject areas where he had responded correctly and alert him in those where he had responded either incompletely or incorrectly.

Marking

Before the test papers were marked each answer was given a value according to its relative importance. An attempt was made to mark with consistency, particularly where it was necessary to interpret partially-correct answers.

COMPILATION AND EVALUATION OF RESULTS

The results for each district were compiled in two ways:

1. The total mark obtained by each testee was tabulated and grouped according to job title. The results for a typical district are given in Table 2.

2. The average mark obtained by each of the three groups was, for each question and part question, tabulated under the appropriate heading as given in Table 3.

Following these analyses, the average mark obtained by each of the three groups, and the number in each, was tabulated for every district in the Province under the appropriate heading, as given in Table 4.

To evaluate the training program in detail it was necessary to analyze the responses to each question and part question as made by the patrolmen, night patrolmen, and hired truckers in each district, and in the Province as a whole. The degree of accuracy to which each group in each district answered was expressed as a percentage and tabulated as in Table 3. Similarly, information for each group at the Provincial level was tabulated (Table 5).

TABLE 2

SUMMARY OF TOTAL MARKS OBTAINED IN POST-TRAINING TEST BY TESTEES IN DISTRICT 1

Patrolmen (19)	Night Patrolmen (11)	Hired Truckers (14)
84	78	77
81	72	72
81	72	70
78	69	69
75	69	65
75	66	63
74	65	62
73	59	59
73	40	51
66	34	51
66	27	45
64		41
60		34
59		24
52		
50		
48		
47		
43		
66	59	56

These data were considered indicative of the current level of knowledge in each district. The test score of 75 percent was arbitrarily selected as being indicative of a satisfactory level of knowledge. It was thought that this information shows the effectiveness of the training program in each district. Evaluation of the data in Table 4 shows that there was a spread of 30 percentage points between the lowest combined average mark of 61 percent in district 1 and the highest of 91 percent in district 6. The remaining districts were fairly evenly interspersed between these limits. There

TABLE 3

SUMMARY OF AVERAGE MARKS OBTAINED BY TESTEES IN DISTRICT 1 FOR EACH QUESTION IN POST-TRAINING TEST

Question	Patrolmen (19)	Night Patrolmen (11)	Hired Truckers (14)	Combined Results (44)
1	82	55	82	75
	58	55	50	55
2	63	73	64	66
	84	73	93	84
	58	64	64	61
3	84	82	79	82
4	55	27	29	40
5 (a) (i)	95	90	93	93
(ii)	68	60	79	70
(iii)	5	10	7	7
(iv)	63	70	93	74
(b)	47	25	29	36
6	84	70	79	79
	74	80	79	77
	82	85	64	77
	84	90	79	83
	74	65	57	66
	65	41	43	51
	61	50	50	55
	50	70	79	64
	82	75	71	77
	21	20	50	30
7	63	50	79	65
8	74	80	43	65
9	46	30	21	34
10	95	100	86	93
	79	27	36	52
	47	82	43	55
	100	100	79	93
	21	55	29	30
	37	36	29	34
	5	18	21	14
11	100	90	86	91
	47	10	16	28
	84	70	79	79
	84	70	36	65
	100	100	86	95
	79	80	57	72
	58	90	93	77
	100	100	79	93
	89	90	93	91
	95	60	86	84
12	70	50	21	49
13	39	36	29	35
14	86	59	71	74
15 (a)	94	55	43	68
(b)	78	73	50	68

TABLE 4

SUMMARY OF AVERAGE MARKS OBTAINED IN POST-TRAINING TEST BY TESTEES IN EACH DISTRICT

District	Patrolmen		Night Patrolmen		Hired Truckers		Combined	
	No.	Mark	No.	Mark	No.	Mark	No.	Mark
1	19	66	11	59	14	56	44	61
2	15	78	38	77	24	75	73	77
3	26	78	33	78	20	77	79	78
4	34	71	9	70	77	61	120	65
5	19	77	19	70	25	71	63	73
6	12	91	9	91	0	–	21	91
7	17	78	36	77	4	76	57	77
8	4	89	9	83	0	–	13	85
9	18	75	26	67	7	67	51	70
10	18	75	15	72	21	68	54	72
11	13	82	11	85	7	79	31	82
13	18	88	19	86	6	89	43	87
14	11	81	9	80	10	81	30	81
16	9	80	7	77	0	–	16	79
17	16	91	29	89	5	88	50	90
18	13	69	15	64	9	65	37	66
19	15	80	8	74	9	75	32	77
20	26	74	2	78	0	–	28	74
Total	303	78	305	76	238	69	846	75

was a greater disparity in the average marks of patrolmen, night patrolmen, and hired truckers in those districts with combined average marks at the low end of the scale, than those at the high end. For example, district 1, with a combined average mark of 61 percent, recorded average marks of 66, 59, and 56 percent for patrolmen, night patrolmen and hired truckers, respectively, while district 17, with a combined average mark of 90 percent, recorded comparable average marks of 91, 89, and 88 percent.

The combined average mark in any district was generally assumed to reflect the relative effectiveness with which the training program had been conducted in that district.

TABLE 5

SUMMARY OF AVERAGE MARKS OBTAINED IN POST-TRAINING TEST BY TESTEES IN THE PROVINCE AS A WHOLE

Question	Patrolmen (303)	Night Patrolmen (305)	Hired Truckers (238)	Combined Results (846)	Question	Patrolmen (303)	Night Patrolmen (305)	Hired Truckers (238)	Combined Results (846)
1	95	91	85	91	9	53	50	40	48
	81	79	72	78	10	95	97	85	93
2	84	84	72	80		57	56	36	51
	96	92	88	92		88	94	87	90
	83	82	73	80		96	97	89	94
3	93	93	92	92		70	72	61	68
						45	46	35	42
4	73	66	58	66		54	62	56	58
5 (a) (i)	98	98	94	97	11	97	96	95	96
(ii)	91	89	90	90		58	61	44	55
(iii)	22	23	12	20		89	91	88	89
(iv)	85	91	85	88		91	87	79	86
(b)	52	53	43	50		99	99	93	97
6	87	92	83	87		81	85	77	81
	92	93	91	92		76	80	86	80
	96	95	90	94		93	93	93	93
	94	96	90	94		90	90	87	89
	76	75	69	74		93	90	82	88
	67	63	61	64	12	67	63	38	57
	71	70	64	68	13	53	57	57	56
	84	90	87	87					
	91	90	82	89	14	89	84	77	84
	71	74	62	70	15 (a)	76	67	57	67
7	91	87	85	88	(b)	75	72	60	70
8	78	71	66	73					

This assumption appeared even more valid after comparing the average marks obtained by the patrolmen, night patrolmen, and hired truckers in those same districts.

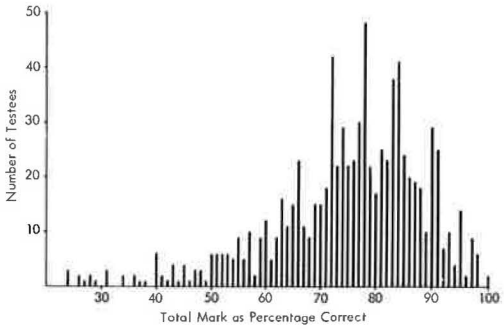

Figure 2. Summary of total marks obtained in post-training test.

CONCLUSIONS

1. The training program was considered successful in that almost 60 percent of the participants scored at least 75 percent on the post-training test. A summary of the total marks obtained by each testee is shown in the form of a frequency-distribution chart in Figure 2. It was felt that a greater degree of success would have been attained if more specific direction had been given to districts as to how the program was to be administered, by whom, and to whom; and if the program had included more follow-up.

2. The post-training test was not in all cases administered by the districts in the manner requested. This cast some doubt on the validity of some of the results. It is important that a post-training test be administered under strictly controlled conditions to a sufficiently large, representative sample of the population.

3. Evaluation of the training program would have been somewhat more meaningful had the level of knowledge prior to training been known. Administration of a pre-training test, similar in content to the post-training test, to a representative sample of the personnel to be trained would have provided a sound basis for measuring the effect of the training program.

4. Where questions contained in the post-training test had been poorly answered by a large percentage of the total testees, some difficulty was experienced in ascertaining whether the deficiency lay in the training program or in the specific test question. This emphasizes the necessity of field-testing the training (or testing) materials before distribution, to insure that the personnel to whom they are directed fully understand the content.

5. No attempt was made to determine the effect of the training program on field performance. However, the following observations were made: some districts were of the opinion that the training program resulted in the improved use of salt and an overall reduction in its use. Other districts felt that the emphasis placed on salt in the training program had encouraged some patrolmen to use salt where they had previously used treated sand. This resulted in increased salt consumption, but to what extent this was offset by a decrease in the use of treated sand is not known. In comparison with previous years there was a leveling-off in salt consumption even though the winter maintenance season in question was thought to be worse than usual.

Appendix

POST-TRAINING TEST
(See Following Sample Pages)

District _____

Patrolman ☐

Night Patrolman ☐

Trucker ☐

1. Fill in the blanks.

The standard rate of application for salt is 450 lb. per 2 lane mile of road.

To salt 6 miles of 4 lane highway, you would expect to use 5400 lb. of salt, at the standard rate of application.

2. Fill in the blanks.

A truck has been calibrated to spread salt on a 2 lane highway at the standard rate of application. The speed posted on the dashboard is 18 m. p. h.
How much salt would it spread per mile of driving at the following speeds?

9 m. p. h. 900 lb. per mile
18 m. p. h. 450 lb. per mile
36 m. p. h. 225 lb. per mile.

3. Cross out the incorrect answers.

Driving faster than the posted speed will mean -

~~more salt spread per mile~~
less salt spread per mile
~~no change in salt spread per mile.~~

4. Circle the correct answer.

If you were given the choice of spreading salt in any of the following widths, which one would you choose?

4' 1' 7½' 12' 9' 2' (½') 6'

5. a) Describe where on the pavement (right, left or centre) you would put salt on the following:

1) straight section of road CENTRE
2) curve to the left, super elevated (banked) RIGHT
3) curve to the right, super elevated CENTRE
4) curve to the right, not super elevated CENTRE

b) State one rule to say where on the pavement salt should be spread, whether on a curve or on a straight section of road.

ON THE HIGHEST POINT OF THE PAVEMENT

6. Against the temperatures listed, write down whether you feel the temperature is good, fair, or poor, for salting operations assuming all other conditions to be favourable.

15° F	FAIR TO GOOD	18° F	GOOD
-7° F	POOR	10° F	FAIR
29° F	GOOD	-12° F	POOR
0° F	FAIR TO POOR	23° F	GOOD
12° F	FAIR	-25° F	POOR

7. At 450 lb. per 2 lane mile, how many miles of 2 lane pavement would you expect to salt with a 5 ton load of salt?

22 MILES APPROX.

8. Why is it important to spread salt early in a storm?

SO THAT BRINE WILL FORM UNDER THE SNOW AND PREVENT THE SNOW FROM STICKING TO THE PAVEMENT

9. Why is it important to spread salt early in the day?

TO TAKE ADVANTAGE OF THE SUN, TRAFFIC AND HIGHER DAYTIME TEMPERATURES, WHICH MAKE SALT WORK BETTER

10. Answer 'yes' or 'no' to indicate whether you would or would not use salt given the following conditions. If you are in doubt, or feel you would need more information, leave blank.

Weather	Time	Temp-erature	Forecast	Road Condition	Answer
Started Snowing	11 a. m.	23°	Continuous snow. Steady temp.	Lightly snow covered	YES
Clear	6 a. m.	0°	Clear	Ice patches	YES
Cloudy	4 p. m.	10°	Falling temperature	Ice and snow patches	NO
Sunny	10 a. m.	8°	Clear	Pavement dry Snow blowing across pavement	NO
Sunny	5 p. m.	10°	Clear	Icy	NO
Overcast	9 a. m.	25°	Snow	2" of snow	NO
Sunny	10 a. m.	20°	Clear	Snow pack covered	NO

11. Mark true or false.

True	False	
☑	☐	Salt works better at higher temperatures.
☑	☐	Salt sometimes works at temperatures below 0°.
☐	☑	Traffic has very little effect on how well salt works.
☐	☑	The reason for salting early in the day is to take advantage of lower traffic volumes.
☑	☐	When snow is blowing off the road and is not sticking, the use of salt may cause the snow to stick to the pavement.
☐	☑	Once salt has combined with the snow to form brine, it will not re-freeze even though the temperature goes down.
☑	☐	As long as the temperature is warm enough, the salt will work, no matter what the other weather conditions are like (sun, wind, etc.).
☑	☐	You should never have a plow operating immediately behind a salt truck.
☐	☑	You should never have a salt truck operating immed-iately behind a plow.
☐	☑	After a snow storm has started, it is better to let snow accumulate to at least 1" before salting.

12. Describe what is meant by "a brine sandwich".

BY SALTING EARLY IN THE STORM A LAYER OF BRINE IS FORMED BETWEEN THE SNOW AND THE PAVEMENT

13. At 25° F, how long do you think should be allowed between salting and plowing to allow the salt time to work?

A MINIMUM OF ½ HOUR

14. One of the three things that affects the rate per mile that salt is spread with a hydraulic sander is the speed of the truck. What are the other two?

1. GATE OPENING
2. HYDRAULIC SANDER MOTOR SPEED

15. a) Where would you set the gate opening on a hydraulic sander for salting operations?

AT THE PROPER SETTING FOR SALTING, MARKED ON TRUCK DASHBOARD OR ON THE SANDER BODY

b) At what throttle setting do you run the motor on the hydraulic sander?

FULL THROTTLE