SAE International™

SURFACE VEHICLE INFORMATION REPORT

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Engineering Design Serviceability Guidelines—Construction and Industrial Machinery—Maintainability Index—Off-Road Work Machines

RATIONALE

This document has been reissued to bring it into alignment with the latest SAE format and update the references. SAE J817-1 has been cancelled as the terms and definitions contained within are defined in ISO 8927, “Earth-moving machinery—Machine availability—Vocabulary”. SAE J817-2 is being cancelled and will become SAE J817.

1. SCOPE

This SAE Information Report establishes a point system that encourages ease of maintenance actions on off-road machines. The point system minimizes subjectivity in evaluating maintainability as defined in ISO 8927.

1.1 This document applies to machines defined and categorized in SAE J1116 and ISO 6165.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this report to the extent specified herein. Unless otherwise indicated, the latest issue of SAE and ISO publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J753 Maintenance Interval Chart

SAE J920 Technical Publications for Off-Road Work Machines

SAE J1116 Categories of Off-Road Self-Propelled Work Machines

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
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SAE WEB ADDRESS: http://www.sae.org

2.1.2 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 6165 Earth-moving machinery—Basic types—Vocabulary

ISO 6750 Earth-moving machinery—Operation and maintenance—Format and content of manuals

ISO 8927 Earth-moving machinery—Machine availability—Vocabulary

ISO 12510 Earth-moving machinery—Operation and maintenance—Maintainability guidelines

3. MAINTAINABILITY INDEX

A system for establishing a number to rate an existing or new concept machine. With this system, lubrication and maintenance items are assigned a point value based on certain requirements. These requirements include: location, access, operation, and miscellaneous. The requirements are defined and a procedure with a simple data sheet shows how to develop the point subtotals.

A quantity multiplier may be applied to the subtotal where repetitious, nearly identical items make it appropriate. The product of the subtotal times the quantity multiplier (when used) is multiplied by the frequency multiplier.

Frequency multipliers are numbers that represent various service intervals. The subtotal of each item is multiplied the appropriate frequency multiplier to obtain the point total for each item. The point total of all items is the maintainability index for a machine. A low maintainability index is desirable.

3.1 System

The system to fill out the data sheet requires judgment factors and assigns points to approximate the values used to judge machines in the field. The limits of application are:

a. The maintainability index is not expressed in time or cost.

b. The maintainability index is best used to compare early and late versions of a particular machine, various sized machines in a model line, or similar machines of other manufacturers. It is suggested that the maintainability index not be used to compare vastly dissimilar machines.

c. This is a design guideline and general practice for use by designers of off-road work machines as categorized in ISO 6165 and SAE J1116, as it is felt adherence to this guideline will facilitate machine maintenance. The best consistency of results in comparing more than one machine will be obtained by using the same auditor for comparison audits.

d. Maintenance innovation and technology are constantly improving. The parameters which make up this document may not be the latest.

e. Detailed commentary is essential, especially in high point areas, to fully explain the acceptability or unacceptability of the maintenance item.

3.2 Procedure

List all lubrication and/or maintenance items on the maintenance index data sheet(s), see Figure 1, except for those nearly identical or identical items to be covered by the quantity multiplier. A completed maintenance index data sheet is shown in Figure 2. The items to be listed will be those in the Maintenance Instructions defined in SAE J920 and ISO 6750, which such instructions are published. The Maintenance Charts defined by SAE J753 may be used in the absence of Maintenance Instructions, but it will probably be less inclusive. Excluded items are the first oil changes at less than the scheduled interval and retightening during the first 100 hours. The actual machine (s) shall be used. It will be the responsibility of the auditor to identify obvious errors or omissions in the Maintenance Instructions when preparing maintenance index data sheets. Refueling the machine should be included.

Although not essential, it is desirable to list according to frequency, shortest frequency first, as suggested by the format in Figure 2. Figure 2 will be used as a reference throughout this procedure.

Items that can be continuously monitored from the operator's station are exempt from point assessments. Dipsticks or level indicators are still needed at fill points and will be assessed points at the change interval.

Each phase of a multiple-step operation should be listed and points assessed. For example, an oil change requires draining the crankcase as one operation and filling the crankcase as another operation, so each should be listed. Each item should be listed separately, or combined if nearly identical, through use of the quantity multiplier to give full credit when the number of items is reduced, except when "banking" is used. Banked fittings (two or more of the same interval) shall receive one point for each bank. Banked fittings are defined as a group of fittings in a common location remote from the joints being lubricated.

Search the list under the discussion of requirements—location, access, operation, and miscellaneous—for the characteristics which most closely resemble those of the item being rated. Enter the corresponding point value in the appropriate column. Select the frequency multiplier for the proper interval and enter it in the column for each of the maintenance items listed.

Add the points across the chart for each item and enter this in the subtotal column. Multiply by the quantity multiplier, if used, to determine subtotal 2. Multiply subtotal 2 by the frequency multiplier to find the total for each item. When the totals have been found for all maintenance items, add them down to find the maintainability index for the entire machine.

3.3 Requirements

(See Tables 1 through 5.)

3.3.1 Location

Location refers to the position in which an individual must locate himself in order to do the job. If more than one operation can be accomplished from the same location at the same service interval or multiple thereof, the first operation is assessed points applicable to that location, and the remainder are assessed one point each.

Table 1 shows the positions considered and their respective point values.

3.3.2 Access

Access refers to the ease of reaching a lubrication or maintenance point. If more than one operation can be accomplished through the same access at the same service interval or multiple thereof, the first operation is assessed points applicable to that access and the remainder are assessed one point each.

TABLE 1 - LOCATIONS AND RESPECTIVE POINT VALUES

Positions		Points
a.	Ground level—working upright, within normal reach	1
b.	Ground level—bending or stretching outside normal reach	2
c.	Ground level—squatting, kneeling, or lying (except under the machine)	3
d.	Mount machine—normal reach	10
e.	Mount machine—bending, stretching, or squatting	15
f.	Any position (other than upright) under or within the confines of the machine	25
g.	Requires climbing into position without handrails and/or steps/platforms being provided	50

Accessibility considerations along with their respective point values are shown in Table 1.

TABLE 2 - ACCESSIBILITY CONSIDERATIONS AND THEIR RESPECTIVE POINT VALUES

Accessibility	Consideration	Points
a.	Exposed	1
b.	Exposed—through opening	2
c.	Flip up cover or flap	3
d.	Door or cover—hand operated	4
e.	Door or cover—single fastener	10
f.	Door or cover—multiple fasteners	15
g.	Hood removal	35
h.	Multiple covers—multiple fasteners	50
i.	Radiator guard removal	50
j.	Tilt Cab	75
k.	Crankcase/drivetrain guard removal—hinged and bolted	75
	—bolted only	100

3.3.3 Operation

Operation refers to the action required to perform the servicing of the listed items.

The operation considerations and their respective point values are grouped into categories of similar actions for easy reference. They are shown in Table 3.

TABLE 3 - OPERATION CONSIDERATIONS AND THEIR RESPECTIVE POINT VALUES

Operation	Considerations	Points
Compartment Checking (Liquid)		
a.	Visual check	1
b.	Dipstick	3
c.	Screw cap—hand removable	4
d.	Multiple screw cap—hand removable	6
e.	Screw cap or plug requiring tool	8
f.	Multiple screw cap or plug requiring tool	10
Component Checking		
a.	Visual check	1
b.	Hand check of belt tension	2
c.	Non-precision tool (includes tire pressure check or torque wrench)	5
d.	Precision tool	10
Lubricating		
a.	Fitting (or bank of fittings)	1
b.	Fitting requiring special adapter	3
c.	Brush on lube	5
d.	Oil can lube	5
e.	Fitting requiring secondary action, such as hand rotating shaft to get fitting to accessible location	5
f.	Hand packing (each)	20

TABLE 3 - OPERATION CONSIDERATIONS AND THEIR RESPECTIVE POINT VALUES (CONTINUED)

Operation	Considerations	Points
Draining		
a.	Drain valve—hand operable	1
b.	Drain valve—tool required	3
c.	Horizontal plug	6
d.	Vertical plug	8
e.	Cover plate	10
f.	Multiple plugs or covers	15
Filling		
a.	Hand removed cap	1
b.	Tool removed cap or plug—vertical	3
c.	Awkward access to filler because of interfering parts or excessive slope of filler tube	8
d.	Tool removed plug-horizontal	10
e.	Requires pump to fill (i.e., differential under machine)	10
f.	Multiple caps or plugs	15
Cleaning		
a.	Blow with air	3
b.	Single bath wash	5
c.	Multiple bath wash or wash and oil	10
d.	Clean reservoir by solvent or similar technique	10
Filter Replacement		
a.	Spin on (vertical base up)	1
b.	Spin on (base up inclined more than 15 degrees)	3
c.	Single fastener not requiring tool	4
d.	Single fastener requiring tool	5
e.	Multiple fastener not requiring tool	6
f.	Multiple fastener requiring tool	7
Adjustment		
a.	Single step	2
b.	Multiple step	4
c.	Multiple location multiple step	10

3.3.4 Miscellaneous

Items in this list cannot be categorized under the headings in Table 3. These requirements are generally considered undesirable and as such should be avoided if possible. In effect, the point values listed or miscellaneous items are punitive points. The requirements for caution can be established by the manufacturer's Maintenance Instructions, by Warning and Cautions affixed to the machine or by the judgment of the auditor.

The miscellaneous considerations are shown in Table 4.

TABLE 4 - MISCELLANEOUS CONSIDERATIONS AND THEIR RESPECTIVE POINT VALUES

	Consideration	Points
a.	Drainage indirectly collectible into container (requires hose or pipe)	2
b.	Interval not in conformance with SAE J753 or ISO 6750	2
c.	Bleeding required	3
d.	Priming required	3
e.	Special tool	4
f.	Inadequately identified	4
g.	Filler size inadequate	5
h.	Vulnerable to contamination	5
i.	Need to start engine	5
j.	Torquing required (per fastener)	5
k.	Drain and wash filter housing	8
l.	Need for special instruction	10
m.	Need to operate or position machine (includes warm-up)	10
n.	Unable to collect fluid	20
o.	Inadequate clearance for required operation	20
p.	Two persons required	40
q.	Requires use of ladder separate from machine	50
r.	Operation requiring caution	100
s.	Position requiring caution	100

3.3.5 Frequency Multiplier (Maintenance Interval)

Maintenance interval refers to the frequency of performing a lubrication or maintenance item. Requirements for one-time only, scheduled retightening or lubricant changes for new machines with less than 100 hours on them will not be considered in determining maintenance index points. The frequency multipliers are assigned as shown in Table 5.

TABLE 5 - FREQUENCY MULTIPLIERS

	Maintenance Interval	Frequency Multiplier
a.	1000 hours—Semi-annually, or greater	1
b.	500 hours—Quarterly, or as required	2
c.	250 hours—Monthly	4
d.	100 hours—Semi-monthly	10
e.	50 hours—Weekly	20
f.	10 hours—Daily	50

The hour intervals listed conform to Annex B of ISO 6750 and SAE J753. If intervals other than those shown are used, apply the frequency multiplier of the nearest SAE Recommended Practice interval plus a miscellaneous penalty of two points.

Each lubrication and maintenance item is assigned a frequency multiplier once—the most frequent interval performed. For example, a schedule that stipulates that the engine oil level must be checked daily would be recorded on the form only once. This item would not enter the count again, even though it may be performed during a monthly oil change.

4. SUMMARY

Any items which have a high point value must be carefully scrutinized. In addition to offering an excellent opportunity for a reduction in the maintenance index, items with a high point value emphasize maintenance areas which are likely to be skipped by the serviceman because of the difficulty involved. Improvement in these areas can reduce the risk of machine or component failure because of neglect, as well as reduce critical machine downtime for periodic maintenance.

There are maintenance reduction possibilities not included in the point scores but still of value to the user. Examples include:

a. Minimum number of liquid types,

b. Standardized filter elements,

c. Common location of maintenance items on a machine family.

5. NOTES

5.1 Marginal Indicia

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE OFF-ROAD MACHINERY TECHNICAL COMMITTEE