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INTERNATIONAL
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SURFACE VEHICLE STANDARD

SAE J1098

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Submitted for recognition as an American National Standard

TON KILOMETER PER HOUR APPLICATION

***Foreword*—**This Reaffirmed Document has been changed only to reflect the new SAE Technical Standards Board Format.

1. ***Scope*—**This SAE Standard establishes the procedures for the application of Ton Kilometer Per Hour (TKPH) rating values for off-the-road tires; utilizing empirical data formula, it describes the procedure for evaluating and predicting off-the-road tire TKPH requirements as determined by a work cycle analysis. This document is applicable to only those tires used on earthmoving machines as defined in SAE J1057, and contains machines referenced in SAE J1116.

1.1 The loads, speeds, inflations, and rim configurations are assumed to be within acceptable industry or manufacturer's prescribed recommendations.

1.2 Other application parameters affecting tires are not included in the scope (for example: flotation, cut, bruise, wear, etc.). These parameters must also be considered for final tire selection, since a tire that maximizes desirable TKPH characteristics will sometimes compromise these other parameters.

1.3 The standards for the productivity of off-the-road machines or tires are not included in the scope.

1.4 The formulae (4.2 and 4.3) are applicable to transport type machines only (that is, trucks, tractor trailers, and scrapers) using Category E Earthmover Service Code Tires. See SAE J751 for service codes.

2. ***References***

2.1 **Applicable Publications**—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J751—Off-Road Tire and Rim Classification—Construction Machines
SAE J1015—Ton Kilometer Per Hour Test Procedure
SAE J1057—Identification Terminology of Earthmoving Machines
SAE J1116—Categories of Off-Road, Self-Propelled Work Machines

3. ***General (Introduction to TKPH)*—**A tire operated at its SAE J1015 TKPH rating will achieve a stabilized temperature under continuous operation without heat damage.

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3.1 Origin of Tire Heat—The temperature described in Section 3 occurs at or near the interface of the undertread and carcass (see SAE J751, Figure 1). This results from the transitory load on the tire crown causing the tire to flex, producing the greatest stresses at or near the junction of the undertread and carcass. The TKPH rating of a tire is established from the maximum stabilized temperature, which the tire can sustain along that interface.

3.2 Effect of Tire Heat—As a tire's temperature increases, its material strengths decrease (Figure 1). Repeated or sustained exposure to excessive temperatures will ultimately produce tire damage.

Heat damage is progressive; it may go undetected or become evident under operating conditions where no apparent cause exists.

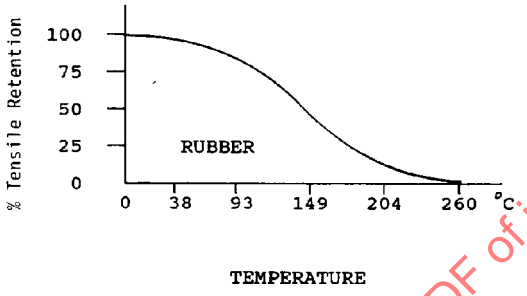

FIGURE 1—TEMPERATURE EFFECTS

3.3 Effect of Load and Inflation—Tire deflection is a function of its load and inflation pressure. When a tire is operated above its normal deflection range due to insufficient inflation pressure relative to the load carried (see 1.2), excessive heat build-up may take place in the tire. This will affect the tire's TKPH capabilities.

3.4 Work Cycle Influence on Tire Temperature—A tire performing within acceptable deflection limits will generally attain an equilibrium temperature within approximately 161 km of service. Various combinations of empty and loaded machine hauls may be programmed to produce acceptable tire temperatures. However, if any operating parameter is altered so as to exceed the tire's TKPH rating, tire heat damage can result. Some examples are:

a. Increase in operating cycle speed. (Consider individual driver practices.)
b. Increase in machine loading due to change in material density and/or machine modification.
c. Adverse weight distribution due to loading techniques or haul road grade.

3.5 Job Site Condition Influence on Tire Temperature—Other items not directly affecting the TKPH calculations, but increasing tire temperature are:

a. Shift schedule increase where equilibrium temperatures had not previously been attained.
b. Ambient temperature in excess of 38 °C.
c. Adverse road conditions (crown, curves, surface, etc.).
d. Excessive brake heat.
e. Vehicle configurations which limit tire cooling.
f. Excessive heat from machine exhaust system.

4. Determining the TKPH Job Rate—This section defines the formula with limitations for calculating the Ton Kilometer Per Hour job rate of an individual tire based on work cycle analysis. For the working formula (4.3), the tire with the highest average load must be considered.

4.1 Nomenclature

H = time, hours, total for the day from the beginning of the first shift to the end of the last shift
J = job rate in TKPH
K = length of round trip, kilometers
K_L = length of loaded haul, kilometers
K_E = length of empty haul, kilometers
N = the number of round trips for the time (H) period
N_E = the number of empty trips for the time (H) period
N_L = the number of loaded trips for the time (H) period
R = tire rating in TKPH as determined by SAE J1015
T_L = tire load, metric tons, on the loaded machine
T_E = tire load, metric tons, on the empty machine

$$T = \frac{T_L + T_E}{2} \text{ (for the tire with the highest average load in metric tons)} \qquad \text{(Eq. 1)}$$

Ton = metric ton, 1000 kg

4.2 General Formula—The general formula is shown in Equation 2:

$$J = \frac{T_L K_L N_L + T_L K_L N_L}{H} \qquad \text{(Eq. 2)}$$

(Refer to 4.1 for Nomenclature.)

Heat generation and retention in a tire is not simply a linear function of the Ton Kilometer Energy Rate. (Refer to 3.1, 3.2, 3.3, 3.4, and 3.5.) Hence, this formula is usable only within certain limitations as defined in 4.4.

4.3 Working Formula—Equation 3 should be used with limitations in 4.4.

$$J = \frac{\text{Highest Avg. Load in Tons} \times \text{Kilometers Traveled}}{\text{Time(Hours)}} \qquad \text{(Eq. 3)}$$

$$J = \frac{TK}{H} \qquad \text{(Eq. 4)}$$

4.4 Limitations—Application limitations vary from one tire manufacturer to another. Individual tire manufacturers should be consulted for deviations from the following general limitations.

4.4.1 LOAD—For loads per tire, refer to current Tire and Rim Association Yearbook 48 km/h Table, the tire manufacturer's 48 km/h publication, or his specific application approval.

4.4.2 DISTANCE—Empty and loaded hauls should be equal and one-way haul distance shall not exceed 16.1 km.

4.4.3 NUMBER OF ROUND TRIPS—If they are not relatively uniform throughout the work day, the maximum round trips per hour shall be used to calculate TKPH job rating.

4.4.4 AMBIENT TEMPERATURE—Consult tire manufacturer for correction formula for ambient temperatures less than or greater than 38 °C.

4.5 Evaluating the Calculated Value—If the Job Rate (J) is equal to or less than the Tire Rating (R), then heat damage should not occur (that is, $J \leq R$). If the Job Rate (J) is greater than the Tire Rating (R) (that is, $J > R$), then the job cycle and/or tire must be changed to meet the conditions of $J < R$.

4.5.1 EXCESSIVE TKPH REMEDIES

a. Reduce T (load)
b. Reduce average speed. Increase delays or reduce N (No. of round trips for time period).
c. Reduce K (round trip length) by locating the haul road to a more direct route.
d. Equip the machine(s) with tires of higher R (TKPH rating).

5. Field Evaluation—When calculated job rates indicate critical TKPH tire temperatures will prevail, a tire temperature study should be made on the job site following the procedure outlined in 4.3 and Section 5 of SAE J1015.

6. Job Analysis—On operations where premature tire removals due to heat separation occur, although TKPH calculations indicate an acceptable job rate, factors contributing to heat damage (see 3.4 and 3.5) must be isolated and corrected.

PREPARED BY THE SAE OFF-ROAD MACHINERY TECHNICAL COMMITTEE SC2—TIRE AND RIM