The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

an American National Standard

SAE J1309

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CRAWLER MOUNTED HYDRAULIC EXCAVATOR TRAVEL PERFORMANCE

1. PURPOSE:

The purpose of this recommended practice is to provide a uniform method of rating travel performance characteristics of crawler mounted hydraulic excavators.

2. SCOPE:

This recommended practice applies to hydraulic excavators as defined in SAE Standard J1057, which are crawler mounted. It describes the methods for calculating and specifying travel performance characteristics. It does not apply to wheel mounted excavators.

3. DEFINITIONS:

3.1 General Items:

3.1.1 Track gage "V_1" and "V_2" width of crawler track assembly "Y," nominal distance between centerlines of drive sprockets and idlers "J_2," and nominal overall length of track assembly "J_4" as used in this recommended practice are defined in SAE Recommended Practice J1193a, and are specified in millimeters.

3.1.2 Rated engine speed "N_R" and peak corrected net brake torque for the specified duty capable of continuous excavator operation "T_T" as used in this recommended practice are defined in SAE Standards J245 and J270, and are specified in revolutions per minute and Newton-meters, respectively,

3.1.3 ROLLING RESISTANCE "R_R": The force, in Newtons, required to sustain track rotation over a given level surface. For the purpose of developing uniform ratings within this recommended practice, a value of 6% of operating weight should be used. This represents a relatively firm soil surface, flexing some under load. "R_R" shall be determined using the following formula:

$$R_R = \left(\frac{6}{100}\right)(W)$$

where "W" is the operating weight as defined in 3.2.1.

3.1.4 PITCH RADIUS "R_P": This dimension shall be the pitch radius of the driving sprockets. It shall be determined using the following formula:

$$Rp = \frac{Pn}{2\pi}$$

where "P" is the track chain pitch in millimeters and "n" is the number of track chain pitches advanced past any fixed point on the machine during one revolution of the sprocket. Pitch radius is specified in millimeters.

3.1.5 TRAVEL MOTOR TORQUE "T_M": Maximum output torque, in Newton-meters, of each hydraulic drive motor, at working hydraulic pressure differential and with output shaft rotating as determined according to SAE Recommended Practice J746b.

3.1.6 HYDRAULIC POWER PUMP DELIVERY "Q_p": Combined output flow, in liters per minute, with engine at "rated engine speed," of all pumps supplying oil to hydraulic travel motors, as determined according to SAE Recommended Practice J745c, and at the hydraulic pressure differential required to sustain travel motion on a level surface having a "rolling resistance" equal to that specified in 3.1.3.

3.1.7 TRAVEL MOTOR SPEED "S_M": Output shaft rotational velocity, in revolutions per minute, as determined according to SAE Recommended Practice J746b, at the hydraulic pressure differential required to sustain travel motion on a level surface having a "rolling resistance" equal to that specified in 3.1.3, and with "Q_p" divided appropriately among the travel motors.

3.1.8 GEAR EFFICIENCY "E_R": Proportion of power, expressed as a percentage, transmitted through the total gear or chain drive system. For the purpose of developing uniform ratings within this recommended practice, an efficiency of 98% should be used for each set of spur gears. Efficiencies used for other gear types and for chain drives shall be at the discretion of the manufacturer, but in no case shall they exceed 98% for each set of gears or sprockets. "E_R" shall be the multiple of all individual gear or sprocket set efficiencies.

3.1.9 GEAR REDUCTION RATIO "R_G": For mechanically driven excavators, "R_G" shall be the total gear reduction ratio between engine crankshaft and sprocket drive shaft. For hydrostatically driven excavators, "R_G" shall be the total gear reduction ratio between travel motor output shaft and sprocket drive shaft.

3.2 Operating Mass: Operating Mass "M" shall be the total mass, specified in kilograms, of a machine equipped as specified in 4.1 and ready to perform its intended function, including all working equipment and tools, a 75 kg allowance for an operator, and the fuel tank filled to one-half capacity, but not including any load in the bucket or other tool. Also included is the mass of all oils and greases necessary to fill oil reservoirs and lubrication compartments to the specified levels.

3.2.1 Operating weight (W) is specified in units of force, Newtons, where:

$$W = 9.807\ M$$

3.3 Rated Travel Speed:

3.3.1 Travel Speed at Rated Engine Speed:

3.3.1.1 For mechanically driven excavators, Travel Speed "S_N" at Rated Engine Speed "N_R" shall be determined using the following formula, and is specified in kilometers per hour:

$$S_N = \frac{(0.00012\pi)(N_R)(R_p)}{R_G}$$

3.3.1.2 For hydrostatically driven excavators, Travel Speed "S_N" at Rated Engine Speed "N_R" shall be determined using the following formula, and is specified in kilometers per hour:

$$S_N = \frac{(0.00012\pi)(S_M)(R_p)}{R_G}$$

3.4 Rated Drawbar Pull:

3.4.1 For mechanically driven excavators, Rated Drawbar Pull "DBP" shall be determined using the following formula, and is specified in Newtons:

$$DBP = \frac{(1000)(T_T)(R_G)\left(\frac{E_R}{100}\right)}{R_P} - R_R$$

3.4.2 For hydrostatically driven excavators having two travel motors, Rated Drawbar Pull "DBP" shall be determined using the following formula, and is specified in Newtons:

$$DBP = \frac{(2000)(T_M)(R_G)\left(\frac{E_R}{100}\right)}{R_P} - R_R$$

For machines having other than two travel motors, appropriate adjustments must be made to the above formula.

3.5 Average Ground Pressure: Average Ground Pressure "P_G" shall be determined using the following formula, and is specified in kilopascals:

$$P_G = \frac{(500)W}{(Y)[J_2+0.35(J_4-J_2)]}$$

This formula makes allowance for some penetration into the supporting soil surface, and the resulting increase in support area.

3.6 Turnability Index:

3.6.1 Turnability Index "T" shall be determined using the following formula, and is specified as a dimensionless number:

$$T = \frac{(OTP)(V_1 \text{ or } V_2)}{W(J_2)}$$

where OTP = One Track Pull (In Newtons)(Maximum Track Pull that can be produced by one track while turning excavator, generally DBP for mechanical, or 1/2 DBP for hydrostatically driven excavators.)

3.6.2 On machines where track gage "V_1" and "V_2" can be retracted or extended, the position(s) used for calculation of "Turnability Index" shall be specified.

3.6.3 Published "Turnability Index" values must be accompanied by a statement which acknowledges that the actual ability to turn will vary depending upon track shoe type and size and ground condition.

3.7 Drawbar Pull to Weight Ratio: Drawbar Pull to Weight Ratio "D_W" shall be determined using the following formula, and is specified as a dimensionless number:

$$D_W = \frac{DBP}{W}$$

4. CONDITIONS:

4.1 The equipment on the basic excavator shall be specified by the manufacturer and shall be the same as that used for "Rated Lift Capacities," "Rated Digging Forces," range diagrams and other standard specifications.

4.2 Permissible Variations: Because of the large number of attachment options and other machine variations available, the manufacturer must publish additional specifications for other machine configurations if these variations would decrease "Operating Mass," "Rated Travel Speed," "Rated Drawbar Pull," "Turnability Index" or "Drawbar Pull to Weight Ratio" or increase "Operating Mass" or "Ground Pressure" by more than 5%, or must specifically state which machine configurations are included in and/or excluded from the specifications.

4.3 For machines having more than one speed range (i.e., mechanical transmission, 2-speed hydraulic motors, series-parallel method of combining pump flows, etc.), the manufacturer shall specify "Rated Travel Speed" and "Rated Drawbar Pull" for each speed range. Published "Turnability Index" and "Drawbar Pull to Weight Ratio" values must be identified with their corresponding speed ranges.

4.4 The manufacturer must be able to verify the published "Operating Mass" within ±5% by actual measurement. The manufacturer must also be able to verify published "Rated Travel Speed" and "Rated Drawbar Pull" specifications by actual tests, with resulting values determined from tests exceeding 95% of the published values. Tests are to be made in accordance with SAE J872a and rolling resistance shown in 3.1.3.

4.5 This recommended practice acknowledges that actual travel performance will vary depending upon track shoe type and size and ground conditions, and that the defined characteristics are representative values for comparative purposes. Travel speed and drawbar pull are interdependent characteristics, with "Rated" values in this recommended practice being defined near the maximum of each. Thus, the two do not occur simultaneously.

4.6 The tolerances in this document are the sum of the actual deviations plus the measuring error.

RATIONALE:

The subject document, prepared by Working Group "C" of SAE Subcommittee 17, provides a uniform method of rating travel performance characteristics of crawler mounted mobile hydraulic excavators as defined in SAE Standard J1057, Identification Terminology of Earthmoving Machines. Wheel mounted excavators have been excluded for two basic reasons:

1) Those travel performance characteristics which are of importance on wheel mounted machines are somewhat different than those of importance on crawler mounted machines. For example, "Ground Pressure" and "Turnability Index" are not applicable to wheel mounted machines, whereas "Turning Radius" would be, but is not applicable to crawler mounted machines.

2) Travel performance characteristics of importance on wheel mounted excavators are common with other wheel mounted machines, and many of these are already covered by other SAE Recommended Practices. Examples of these are: a) Minimum Performance Criteria for Braking Systems for Off-Highway, Rubber-Tires, Self-Propelled Construction Machines - SAE J1152, b) Turning Ability and Off Tracking - Motor Vehicles - SAE J695a, c) Truck Ability Prediction Procedure - SAE J688.

The travel performance characteristics which have been defined in this document are those which are in common usage today with two exceptions:

1) "Turnability Index" is a new term which the Committee does not find in common usage. It is, however, of real importance on crawler mounted excavators, especially those which are hydrostatically driven, and is an item commonly compared and evaluated by manufacturers. The definition used in this document provides a common basis for comparison so long as machines being compared are equipped with similar track shoes. The Committee recognizes differences in the ability of a machine to turn with differences in track shoes and differences in ground conditions, but believes it is not possible to include such factors in the formula.

2) "Drawbar Pull to Weight Ratio" has been used in this document in place of "Gradeability". The Committee is of the opinion that this is the characteristic which is actually desired for comparison in the presently used "Gradeability", however, "Gradeability" can be, and frequently is, limited by engine lubrication, traction, or stability. With these other limitations, "Gradeability" cannot be compared on a uniform basis.

The subject document has been written using SI units to agree with current SAE guidelines. It is also consistent in purpose and scope with other SAE documents applying to hydraulic excavators, including: Hydraulic Excavator Lift Capacity Rating - SAE J1097, Hydraulic Excavator Digging Forces - SAE J1179, Nomenclature and Dimensions for Hydraulic Excavators - SAE J1193, and Hydraulic Excavator Operator Controls - SAE J1177.

"Average Ground Pressure" as defined in this document is identical to PCSA Standard No. 3, except for the use of SI units in this Recommended Practice and English units in the PCSA Standard.