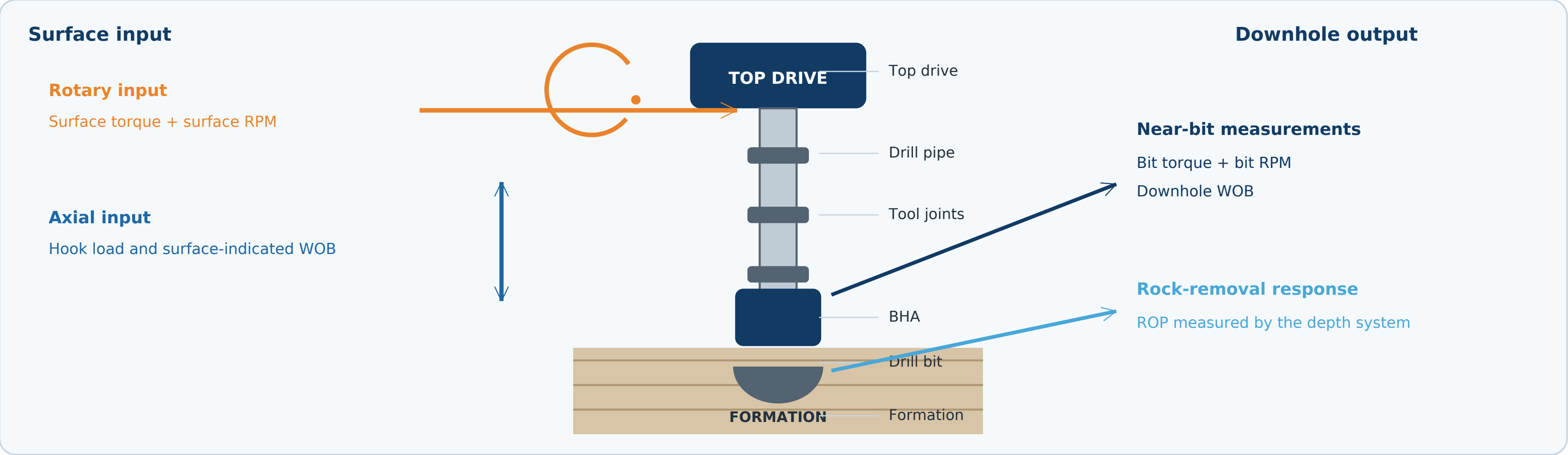
Mechanical Energy Transfer Path

The diagram identifies energy paths and measurement locations; the table defines how each measured value is used.



Parameter	Unit	Measurement location	Engineering use
Surface torque	ft-lb / kN m	Top drive	Mechanical input and connection-load monitoring
Surface RPM	rpm	Top drive	Average rotary input
Hook load	lbf / kN	Hoisting system	Suspended-load and surface-WOB calculation
Downhole WOB	lbf / kN	Near-bit sensor	Actual local axial load
Bit RPM	rpm	Near-bit sensor or motor calculation	Actual cutting speed
ROP	ft/hr / m/hr	Surface depth system	Rock-removal rate

Illustrative calculations - not universal operating limits. Verify against the approved drilling program and component data.

Torque, RPM and Mechanical Power Matrix

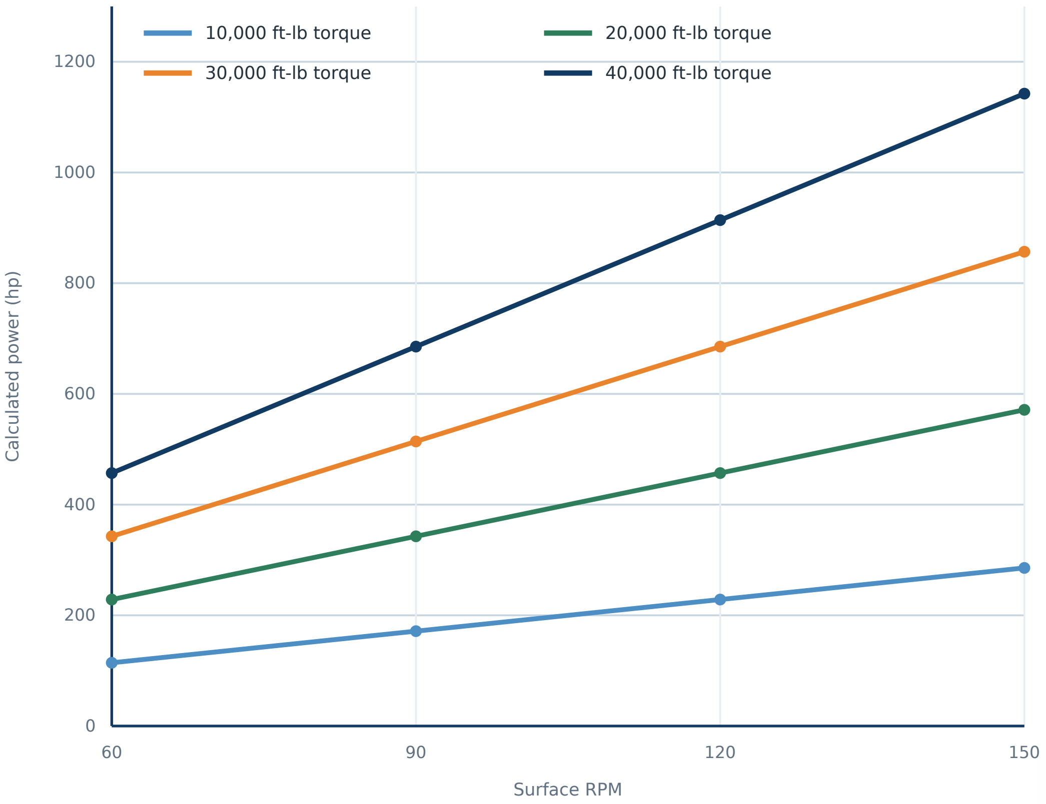
Mechanical power rises linearly with torque and RPM, but calculated input power is not an allowable drill-string rating.

Power (hp) = Torque (ft-lb) x RPM / 5,252

Power (kW) = Power (hp) x 0.7457

Inputs below are illustrative cases, not setpoints.

Mechanical power trend



Torque	60 rpm	90 rpm	120 rpm	150 rpm
10,000 ft-lb	114 hp 85 kW	171 hp 128 kW	228 hp 170 kW	286 hp 213 kW
20,000 ft-lb	228 hp 170 kW	343 hp 256 kW	457 hp 341 kW	571 hp 426 kW
30,000 ft-lb	343 hp 256 kW	514 hp 383 kW	685 hp 511 kW	857 hp 639 kW
40,000 ft-lb	457 hp 341 kW	685 hp 511 kW	914 hp 682 kW	1,142 hp 852 kW

Required verification before using the result

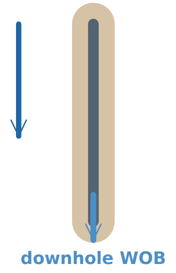
- Calculated power does not equal allowable drill-string power.
- Top-drive capacity does not establish pipe, connection, or BHA capacity.
- Use the lowest applicable limit among pipe body, tool joint, connection, and BHA tools.
- When torque and tension act together, evaluate the applicable combined-load interaction.

Matrix cells show calculated horsepower and metric power for the stated inputs only.

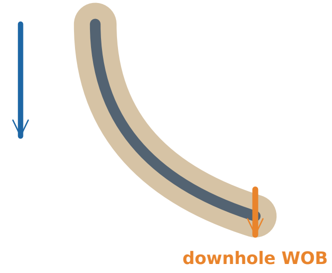
Surface WOB and Downhole Load Transfer

Surface-indicated WOB is inferred from hook-load change; borehole contact and friction determine how much reaches the bit.

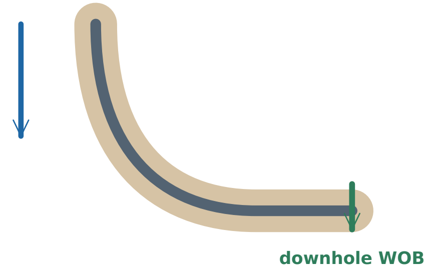
Near-vertical interval Illustrative transfer: 95%



Build section Illustrative transfer: 80%



Horizontal interval Illustrative transfer: 60%



All three cases use the same 40,000 lbf surface-indicated WOB. Friction losses are modeled examples, not fixed field values.

Well condition	Surface-indicated WOB	Modeled friction loss	Estimated downhole WOB	Main uncertainty
Near-vertical interval	40,000 lbf / 178 kN	2,000 lbf / 8.9 kN	38,000 lbf / 169 kN	Low wall contact
Build section	40,000 lbf / 178 kN	8,000 lbf / 35.6 kN	32,000 lbf / 142 kN	Dogleg and stabilizer contact
Horizontal interval	40,000 lbf / 178 kN	16,000 lbf / 71.2 kN	24,000 lbf / 107 kN	Cuttings bed and continuous wall contact

Calculation relationships

Surface WOB = off-bottom rotating hook load - on-bottom rotating hook load

Simplified downhole WOB = surface WOB - incremental slack-off friction

Example: 300,000 lbf off bottom - 260,000 lbf on bottom = 40,000 lbf surface WOB.

Use comparable rotating conditions and a current model; static readings can include additional effects.

Interpretation boundaries

- Pickup drag and slack-off drag differ in direction and should not be substituted for each other.
- Near-bit sensors measure local axial load more directly than a surface subtraction.
- No universal WOB transfer efficiency applies to every horizontal well; update the model as hole condition changes.

Mechanical Specific Energy Calculation

MSE combines axial and rotary energy per unit rock volume; it is most useful as a contextual trend, not a pass/fail number.

$$A_{bit} = \pi \times D^2 / 4$$

$$MSE = WOB / A_{bit} + 120 \times \pi \times Torque \times RPM / (A_{bit} \times ROP)$$

Oilfield-unit form: D in, WOB lbf, torque ft-lb, ROP ft/hr; result in psi.

Baseline input	Value
Bit diameter	8.500 in
WOB	30,000 lbf / 133.4 kN
Torque	8,000 ft-lb / 10.85 kN m
RPM	120 rpm
ROP	120 ft/hr / 36.6 m/hr
Calculated bit area	56.75 in2

Baseline MSE contribution

Baseline total MSE = 53.68 ksi. Rotary input dominates this illustrative case.

Changed input	Case value	Other inputs held constant	Calculated MSE	Interpretation limit
Baseline	As listed	-	**53.68 ksi**	Reference case only
Higher WOB	40,000 lbf	Torque, RPM, ROP	**53.85 ksi**	Higher MSE does not prove better drilling
Higher torque	10,000 ft-lb	WOB, RPM, ROP	**66.96 ksi**	May reflect cutting or borehole friction
Higher RPM	150 rpm	WOB, torque, ROP	**66.96 ksi**	Vibration can distort the apparent benefit
Higher ROP	150 ft/hr	Mechanical inputs	**43.05 ksi**	Confirm hole cleaning remains adequate

Interpretation boundary

Use MSE as a trend with formation, bit, hydraulics, and vibration context. Surface torque includes borehole friction, so it is not all delivered to rock cutting.

Required Data and Interpretation Boundaries

The calculation quality cannot exceed the quality, resolution, and relevance of its mechanical, trajectory, and downhole inputs.

Mechanical inputs

- Bit diameter
- Surface torque
- Surface RPM
- Hook load off bottom
- Hook load on bottom
- Surface WOB
- ROP

Trajectory and contact

- Well inclination
- Well azimuth
- Friction factor
- BHA configuration
- Hole condition
- Stabilizer contact

Tubular and fluid

- Pipe OD and ID
- Connection data
- Mud density
- Tool-joint dimensions
- Current component condition

Downhole data

- Downhole WOB, if available
- Near-bit RPM
- Downhole torque or dynamics
- Motor output, if installed
- Sensor depth and time alignment

A calculation record should retain the data source, unit system, time/depth alignment, assumptions, model version, and applicable component limits.

Data condition	Recommended treatment
Surface data only	Use as an operating trend with explicit modelling uncertainty.
Surface data plus torque-and-drag model	Estimate load transfer along the planned or surveyed trajectory.
Surface data plus downhole dynamics	Compare actual near-bit behavior with surface inputs and model predictions.
Missing tool or connection data	Hold the operating assessment until the relevant limits are confirmed.
Changing hole condition	Update the model instead of retaining one fixed friction assumption.

Calculation boundary

Do not convert these illustrative examples into field setpoints. Use measured dimensions, current inspection condition, manufacturer data, the approved well plan, and the operator's applicable design and monitoring method.

Technical basis

API RP 7G (applicable edition); ISO 11961:2018; Teale, R. (1965), The Concept of Specific Energy in Rock Drilling; manufacturer tool data; approved torque-and-drag and dynamics methods.