# TECHNICAL MEMORANDUM

26 August 2021

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FROM: Alex Doll, Alex G Doll Consulting Ltd.
SUBJECT: GRINDING MILL MOTOR POWER DEFINITIONS

## Summary:

Grinding circuit power is commonly used as a defining parameter in circuit design and analysis. However, the circuit power can be defined at a number of points, and depending upon the use of the power, different system losses must be applied to the power reported.

## Discussion:

Per the diagram on the following page, the specification of mill power differs depending upon what the definition is to be used for. Operating costs are measured at the utility connection or at the power station, and include all the system losses between the mill shell and the utility connection.

The sizing methods for grinding mills differ on the definition of where a mill's power is specified. The Bond work index, Morrell Mi, and Minnovex CEET methods specify power "power at the pinion" (equivalent to "at the mill shell" on gearless drives). The JK SimMet calculation specifies power measured by the motor input (based on a Morrell power C-model, usually corrected to the motor input). The indication on the plant's distributed control system (DCS) is typically tapped from the MCC room or electrical house, though it may be 'corrected' mathematically to another position, such as the motor output for gearless drives.

The nature of the mill motor affects the level of power losses between the different components. Gearless motors have no loss-generating mechanical connections between the motor output and the mill shell (the mill shell is actually the motor's rotor), so it has 100% mechanical efficiency in transmitting motor output to the mill shell. Synchronous motors have 98.5% efficiency in converting motor output to power at the mill shell due to the pinion and gear. Wound rotor motors with gearbox reducers have a 98.5% gearbox efficiency and 98.5% pinion efficiency resulting in an overall 97% efficiency converting motor output to power at the mill shell.

Losses are multiplied to derive total losses. For example, converting a variable speed synchronous motor mill shell power to DCS power requires an overall efficiency of $0.985 \times 0.96 \times 0.98 = 0.927$. Thus, a motor applying 10 MW of power to the mill shell will indicate 10.8 MW of power at the DCS. Operating the motor for one hour would consume 11.0 MW·h of power from the utility assuming a 1.0 power factor
($0.985 \times 0.96 \times 0.98 \times 0.98 \times 1.0 = 0.908$ overall losses).

Certain drives provide the DCS with a software-corrected mechanical output power rather than a motor electrical input power. Gearless drives and systems like ABB's ACS6000 all report mechanical output power.

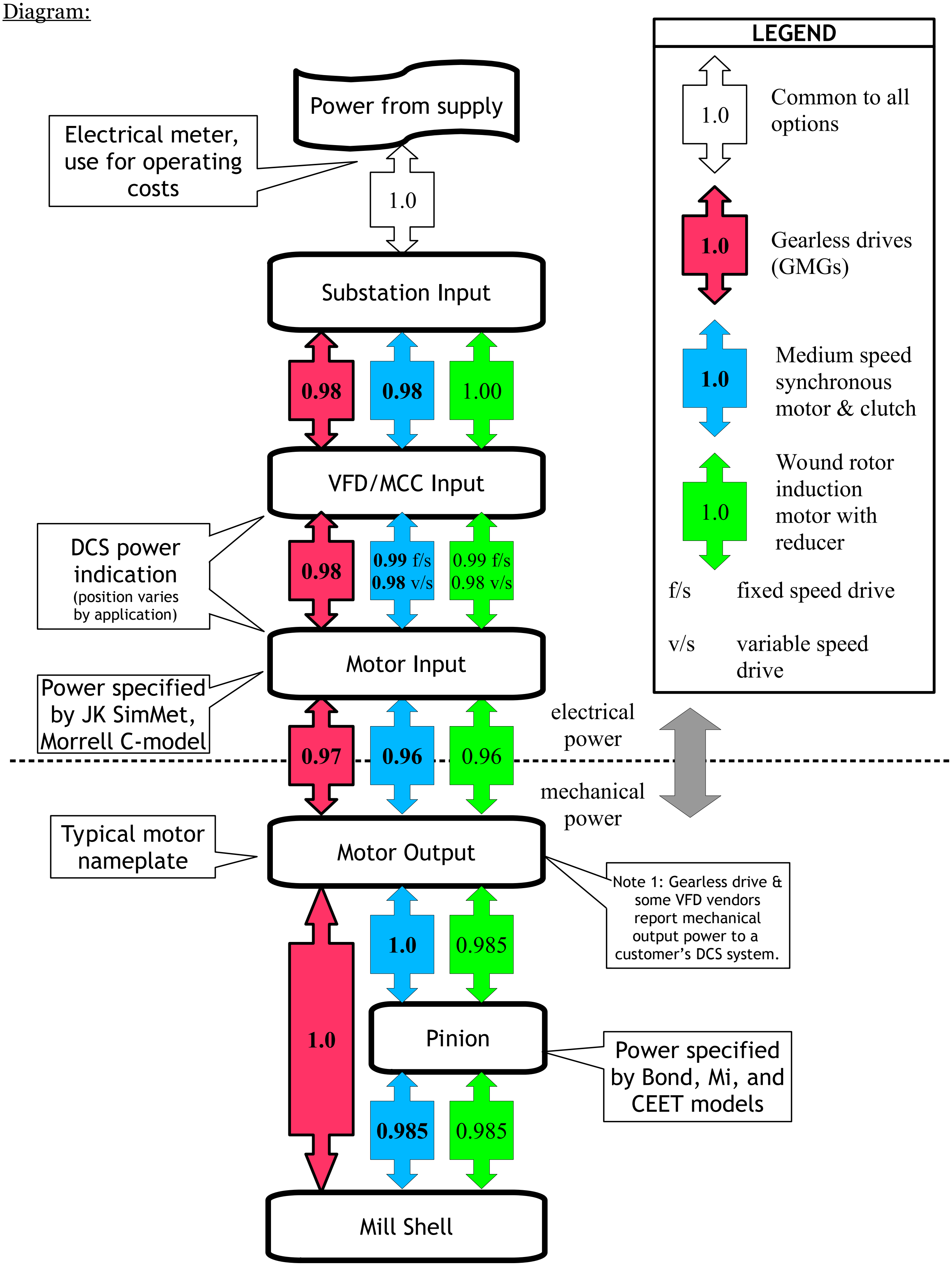
Financial calculations should be based on the combined losses up to the "Power from supply" connection point. Thus, the operating cost should be based on the DCS power reading divided by ~0.97. Auxiliary motors (motor cooling fans, coolant circulating pumps, etc.) must also be accounted when doing financial calculations.

## Credits & Comments:

Losses are based on values derived by Mac Brodie P.Eng and Derek Barratt P.Eng. Power reading position by Mark Richardson (Contract Support Services) and Guillaume Chiasson (SGS Lakefield). Some values adapted from Ploc & Peters, IMPC 2010.

Values are provided as "typical" as assume unit power factor. Losses are also affected by factors such as conductor length, conductor thickness, altitude, presence of step-down transformers and power factor corrections. Check a minesite's electrical documents and motor name-plates for more exact values.

Diagram:



LEGEND
1.0
Common to all options
1.0
Gearless drives (GMGs)
1.0
Medium speed synchronous motor & clutch
1.0
Wound rotor induction motor with reducer
f/s fixed speed drive
v/s variable speed drive
Power from supply
Electrical meter, use for operating costs
1.0
Substation Input
0.98
0.98
1.00
VFD/MCC Input
DCS power indication (position varies by application)
0.98
0.99 f/s 0.98 v/s
0.99 f/s 0.98 v/s
Motor Input
Power specified by JK SimMet, Morrell C-model
0.97
0.96
0.96
electrical power
mechanical power
Typical motor nameplate
Motor Output
Note 1: Gearless drive & some VFD vendors report mechanical output power to a customer's DCS system.
1.0
1.0
0.985
Pinion
Power specified by Bond, Mi, and CEET models
0.985
0.985
Mill Shell