Estimation of Metabolic Rate
Adapted from ISO Components Method

Components	Initial Data	Values	Rate of Energy Expenditure [W]
Base	---	---	80
Posture	Sit Stand	20 45	
Activity	Body Involvement N H 1A 2A WB Effort L M H VH	See Activity Matrix	
Horizontal Rate of Travel - Average in Feet / Min	Estimate [ft/min]: 2.5 mph = 220 ft/min	1.0 x Rate [ft/min]	
Vertical Rate of Travel - Average in Feet / Min	Estimate [ft/min]: 1 step / 2 sec = 15 ft/min (ie, 6-inch step)	17 x Rate [ft/min]	
Total Metabolic Rate (Sum the Last Column)			

	Effort			
Activity	Light	Moderate	Heavy	Very Heavy
None	0	0	0	0
Hand(s) Only	25	55	70	80
One Arm	65	100	135	170
Both Arms	115	155	190	230
Whole Body	225	340	505	700
	Can be performed indefinitely with ease	Can be performed indefinitely with some effort	Can be performed for 30 - 60 min before a break	Can be performed for about 15 min before a break

Estimation of Metabolic Rate
Adapted from Qualitative Method of Bernard and Joseph

Components	Initial Data	Values	Rate of Energy Expenditure [W]
Base	---	---	100
Arms	AI 0: Sedentary 0: Little Hand/Arm Movement 1: Hands Move Mostly < 20 in 2: Frequently Hands Move > 20 in 3: Bend, stoop, extended reaches	0 69 98 127 156	
Lift (not appropriate for heavy manual materials handling)	Weight of Parts and Tools [lb] Wt: < 4 4 to 11 > 11 WI: 1 2 3 Frequency [cycles / min] Frq: < 2 2 to 5 > 5 FI: 1 2 3	AI x WI x FI x 5.1	
Walk - Average in Feet / Min (Do not include push / pull)	Estimated Rate [ft/min]: 2.5 mph = 220 ft/min	1.0 x Rate [ft/min]	
Push / Pull	Average Force [lb] = _____ {F} Average Distance per Minute [ft/min] = _____ {D}	(6 + 1.3 x F) x D / 3	
Vertical Rate of Travel - Average in Feet / Min	Estimated Rate [ft/min]: 1 step / 2 sec = 15 ft/min (ie, 6-inch step)	17 x Rate [ft/min]	
		Total Metabolic Rate (Sum the Last Column)	

Estimation of Metabolic Rate for General Activities

Walking/Carrying (S from 50 to 85 m/min or about 2 to 3 mph)
V_{O2} [mL/kg.min] = 3.5 + 0.1 * S + 1.8 * G * S
S = Speed [m/min]
G = Grade [fraction of the elevation / distance]
Adjustments to V_{O2} for walking at about 90 m/min or 3.3 mph

Terrain	Correction Factor
Paved Road/Grass Track	1.0
Plowed Field	1.5
Hard Snow	1.6
Sand Dune	1.8

Running (S > 130 m/min or about 5 mph)
V_{O2} [mL/kg.min] = 3.5 + 0.2 * S + 0.9 * G * S
S = Speed [m/min]
G = Grade [fraction of the elevation / distance]

Stairs -- Ascent
V_{O2} [mL/kg.min] = 1.2 + 1.74 * S_v
S_v = Vertical Speed [m/min]

Stairs -- Descent
V_{O2} [mL/kg.min] = 1.2 + 0.6 * S_v
S_v = Vertical Speed Downward [m/min]

Stool Stepping
V_{O2} [mL/kg.min] = 5.4 + 2.8 * S_v
S_v = Vertical Speed [m/min]

Ladder Ascent
V_{O2} [mL/kg.min] = 8.0 + 2.0 * S_v
S_v = Vertical Speed [m/min]

Ladder Decent
V_{O2} [mL/kg.min] = 5.7 + 0.49 * S_v
S_v = Vertical Speed Downward [m/min]

Shoveling
V_{O2} [mL/min] = 500 + 7.0 * W_e
W_e = External Work [kg.m/min]

Cycle or Cranking (**External Work by Arms or Legs**)
V_{O2} [mL/min] = 300 + 2.0 * W_e
W_e = External Work [kg.m/min]

Estimation of Metabolic Rate for Materials Handling Tasks

Adapted from Garg

M = Metabolic Rate [kcal/min]
BW = Body Weight [kg]
L = Average Load [kg]
F = Average Rate [move/min]
H = Height of Lift [m]
D = Distance of Horizontal Move [m]
R = Slide (Push/Pull) Force [kg]
S = Walking Speed [m/min]
G = Grade [%]

Idle (Sit/Stand) and Hold

$$M[kcal/min] = 0.024*BW + 0.06*L$$

Walking / Carrying

$$M[kcal/min] = 0.024*BW + 0.74 + 0.0248*BW*(S/60)^2 + 0.0434*L*(S/60)^2 + 0.08*L + 0.00379*(BW+L)*G*(S/60)$$

Lifting (Stoop)

$$M[kcal/min] = 0.024*BW+(0.0013*BW+0.0144*L*H)*F$$

Lifting (Arm)

$$M[kcal/min] = 0.024*BW+(0.00025*BW+0.0208*L*H)*F$$

Lifting (Squat)

$$M[kcal/min] = 0.024*BW+(0.00205*BW+0.025*L*H)*F$$

Lowering (Stoop)

$$M[kcal/min] = 0.024*BW+(0.00107*BW+0.00675*L*H+0.0104)*F$$

Lowering (Arm)

$$M[kcal/min] = 0.024*BW+(0.000372*BW+0.012*L*H)*F$$

Lowering (Squat)

$$M[kcal/min] = 0.024*BW+(0.00204*BW+0.00701*L*H)*F$$

Horizontal Movement of Load

$$M[kcal/min] = 0.024*BW+0.02*L*D*F$$

Slide (Push/Pull) Load

$$M[kcal/min] = 0.024*BW+(0.09*D+0.025*R*D)*F$$