

# A respiration chamber for exercising Polar Bears

N. A. ØRITSLAND, C. JONKEL & K. RONALD

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An open circuit respiration chamber which allows determination of the oxygen consumption of Polar Bears (*Ursus maritimus*) walking on a treadmill is described and discussed. Oxygen consumption of a 235 kg Polar Bear increased with walking speed at a rate of more than two times that found for most mammals. The high energy cost of walking may be due to lateral movements of the heavy legs and paws.

N. A. Øritsland, *Institute of Zoophysiology, University of Oslo, Blindern, Norway.*  
C. Jonkel, *School of Forestry, University of Montana Missoula, Montana 59801, U.S.A.*

K. Ronald, *College of Biological Science, University of Guelph, Ontario, Canada.*

Measurements of the oxygen consumption of walking Polar Bears are of interest both for energetic ecological analysis and in the context of studies on animal locomotion. Here is described an open circuit respiration chamber that allows determination of the oxygen consumption of Polar Bears walking on a treadmill.

## MATERIALS AND METHODS

A hydraulic powered treadmill with continuous speed control was installed in a building at Fort Churchill, Manitoba. The treadmill track was 1.3 cm thick, 91 cm wide, and made of rubber on 3 ply nylon.

A steel chamber 2.87 m long, 1.32 m high and 1.13 m wide was mounted on top of the treadmill. The weight of the chamber was supported by the treadmill frame and only light metal and plastic skirts were in contact with the moving track (Fig. 1). Sheet steel (12 gauge) reinforced with angle irons

was used for chamber walls. Three window openings 60 by 60 cm were cut in the walls and barricaded with 1 cm steel bars spaced 10 cm apart and welded to the inside of the walls. A 30 by 30 cm window was cut in the roof allowing light from an outside bulb. All cracks were sealed with silicone sealant or an oil based paint while front and rear access doors were sealed with grease. A mixing fan protected by a steel basket was placed in the front end of the chamber, while a centrifugal fan evacuated air through a tube 5 cm wide inserted into the rear end of the chamber. Exhaust air was collected on a 350 l Collins gasmeter, and concentrations of carbon dioxide and oxygen were determined using the Scholander  $1\frac{1}{2}$  cc analyzer. Principal design and details of construction are presented in Fig. 1.

A 235 kg male Polar Bear about 4 years old was caught near Churchill during November, 1974. He was trained to use the treadmill during parallel studies. He was subjected to the respiration chamber studies after about 4 months in captivity.

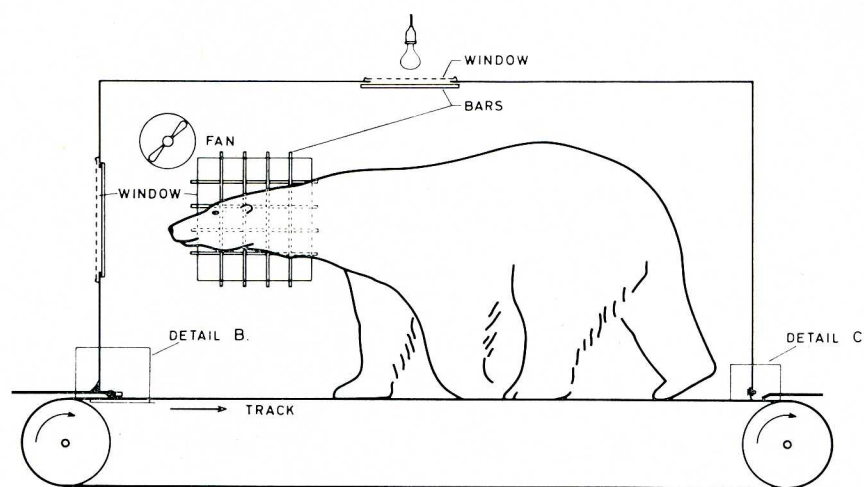
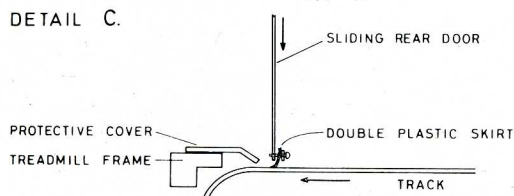
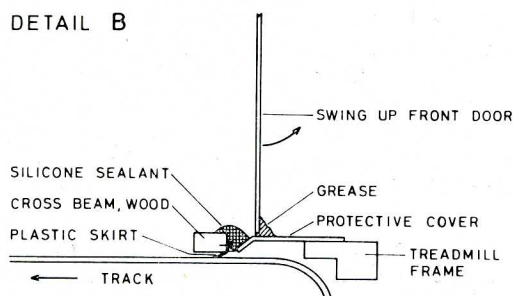
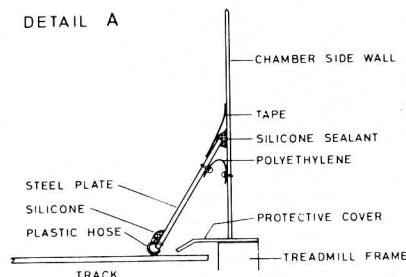


Fig. 1. General description of treadmill: Belt is 91 cm (3') wide on 25.4 cm (10") roller bed pulley centres with rear 'take up' bearings to permit belt tensioning and pulley alignment. A 10 h.p. variable drive unit (Carter size 5 A) gives, nominally, belt speeds from

zero to 30 km/hr.

Respirations chamber ( $2.87 \times 1.32 \times 1.13$  m): Sheet steel walls with three  $60 \times 60$  cm windows barred with 1 cm steel bars spaced 10 cm apart. Steel skirts (detail A) hinged to the walls ensure that air inflow occurs only at the track. Both ends of the steel skirts are extended by means of plastic strips (not shown in figures) pressing against the doors. Detail B: Hinged front door. Detail C: Sliding rear door.



## RESULTS AND DISCUSSION

Chamber design was based on experience with Polar Bears captured in culvert traps and foot snares. Upon capture, a Polar Bear will normally try to break loose for only a few minutes before settling down to the new situation. Further introduction of new objects into the area of confinement are met with fear or aggression, however. Thus, earlier attempts at introducing a mobile respiration chamber inside a cage mounted over the treadmill failed, while the present chamber functions as a cage, and seems to be accepted as such by the experimental animal.

During experiments clear perspex is placed over the window openings. Eleven independent experimental runs were obtained. A ventilation rate of about 400 l/min was sufficient to keep carbon dioxide concentrations below 1 per cent when the Polar Bear was walking at speeds up to 1.5 m/second. Air temperatures ranged between  $-11$  and  $-5^{\circ}\text{C}$ . An equilibration time of 30 to 45 minutes elapsed before exhaust gas was collected for analysis. Three gas collections were made for

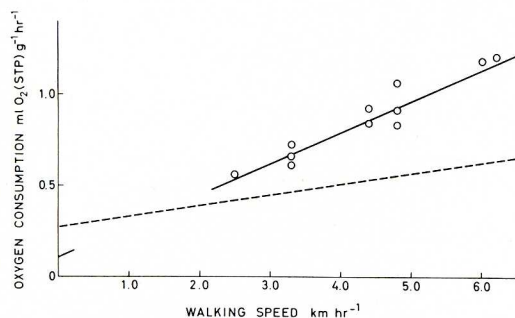


Fig. 2. Oxygen consumption of a 235 kg walking Polar Bear. Regression line. - - - Predicted relation (Taylor et al. 1970).

each run and three parallel concentration analyses were made from each collection. Linear regression analysis of the results (Fig. 2) gave:

$$V_{O_2} = 0.11 + 0.17 V \text{ ml } O_2 \cdot g^{-1} \cdot hr^{-1}$$

( $r = 0.96$  s.e.e. = 0.06)

where  $V$  is the walking speed in km/hr.

By comparison, a general formula for the energy cost of running (Taylor et al. 1970) yields the following prediction equation for a 235 kg homeotherm:

$$V_{O_2} = 0.27 + 0.06 V \text{ ml } O_2 \cdot g^{-1} \cdot hr^{-1}$$

Thus, the present measurements indicate a more than twofold higher cost of walking than normally predicted. A comparable higher cost has been reported for man (Taylor et al. 1970) and the *Rhea* (Taylor et al. 1971) while values about 50 per cent above the predicted have been reported for the chimpanzee (Taylor & Rowntree 1973). The high cost, i.e. low efficiency of the Polar Bear may be due to its heavy legs and paws that conspicuously show a sideways movement during walking.

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