



DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF

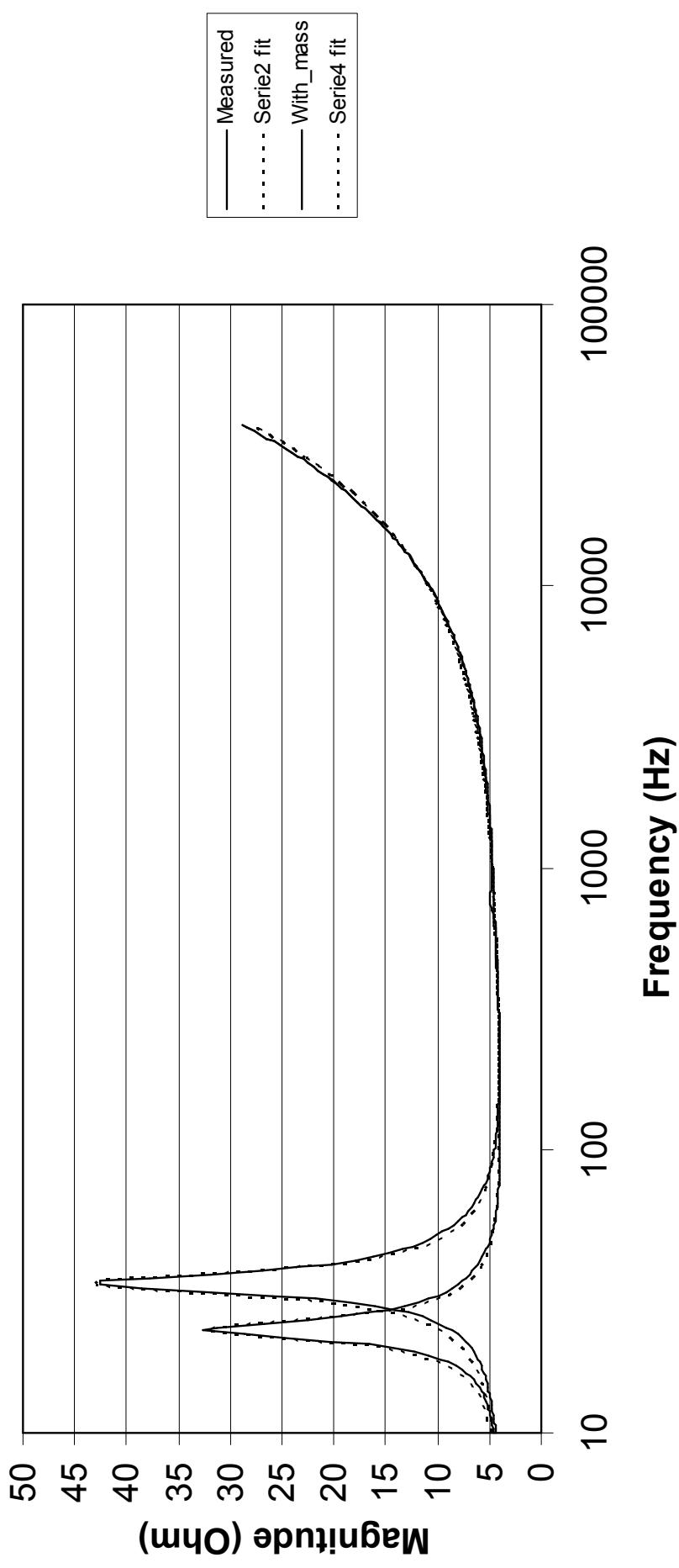
# Losses in Loudspeaker Enclosures

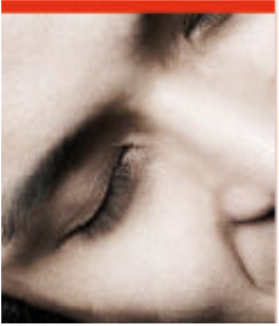
Claus Futtrup



DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF

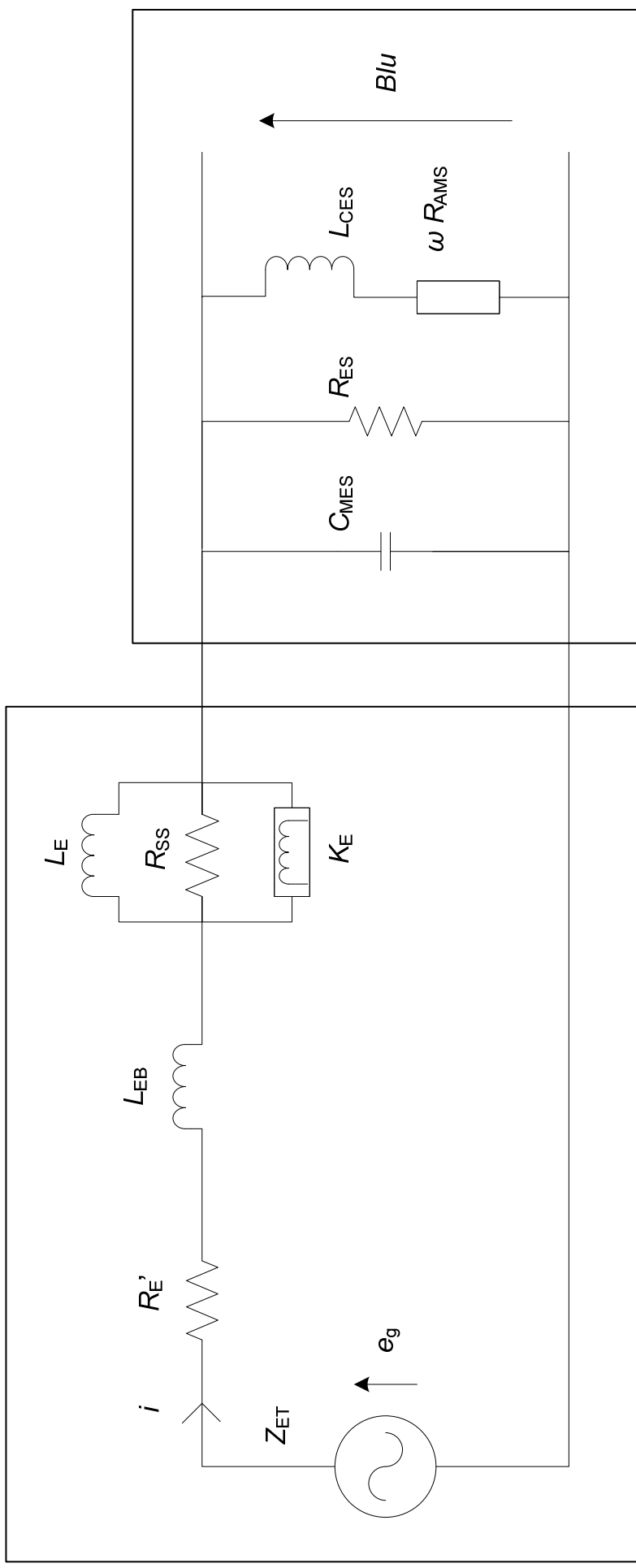
## ■ Zres – free air, without / with added mass





DANISHI DESIGNED AND MANUFAC  
TURED ADVANCED PATENTED TEC  
HNOLOGIES. COMPONENTS OF

## Transducer model with FDD ( $R_{AMS}$ )



$Z_E$



DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF

## ■ R. Small on Qp, Ql and Qa - conclusions

Qp – between 50 and 100

Qa – typically 100 or more

Ql – between 5 and 20

Quote: The last result is surprising, because the enclosure tested well built and appeared to be leak free...

Quote: ... leads to the conclusion that the measured leakage in apparently leak-free systems is not an error of measurement but an indication that the actual losses in the system enclosure is not constant with frequency...

Link to paper ([PDF](#)) page 5



## ■ R. Small, Graph with $Q_p$ , $Q_l$ and $Q_a$

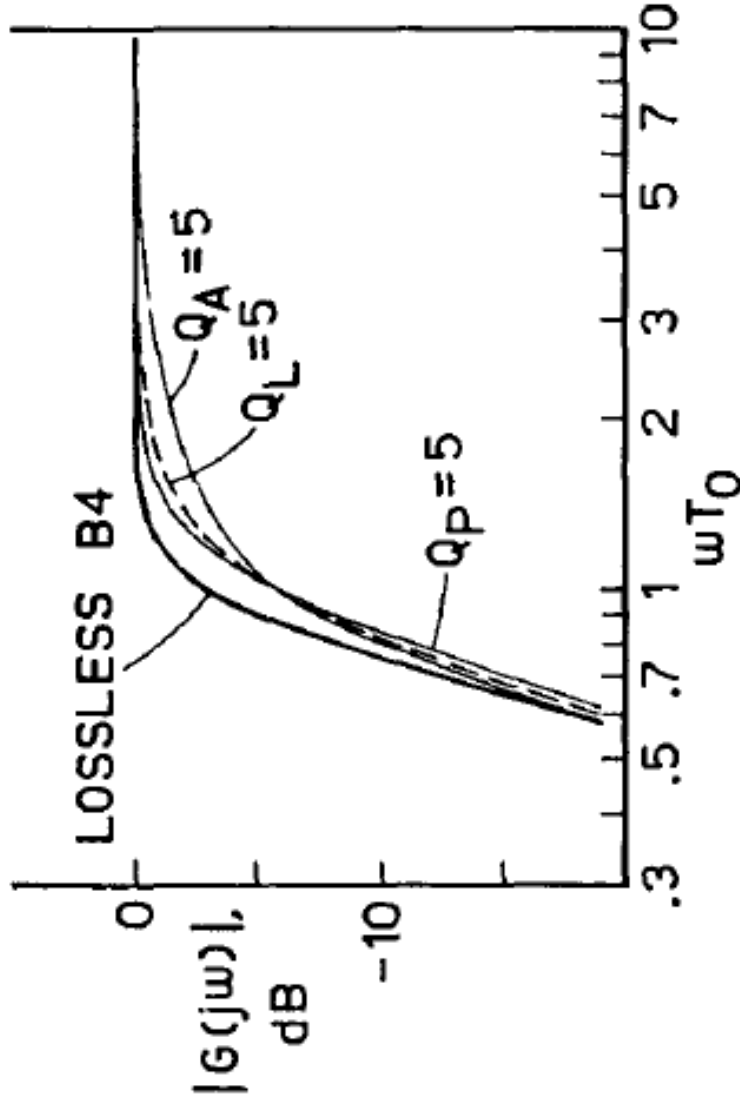
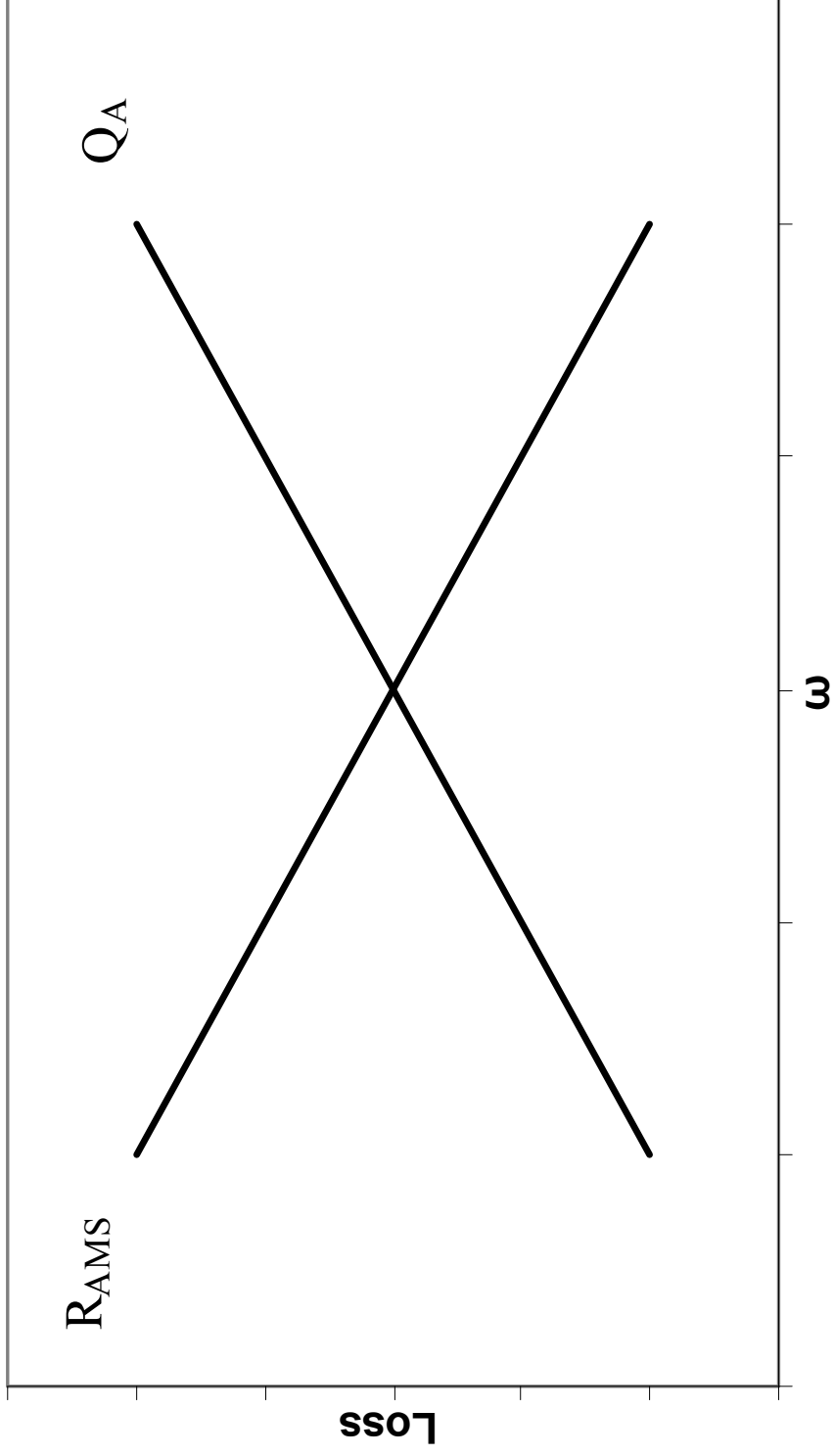
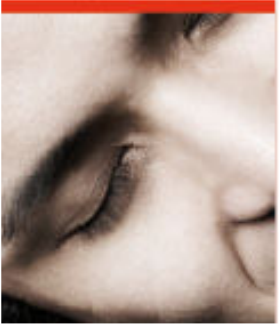


Fig. 4. Effects of enclosure-circuit losses on response of a lossless B4-aligned vented-box loudspeaker system (from simulator).



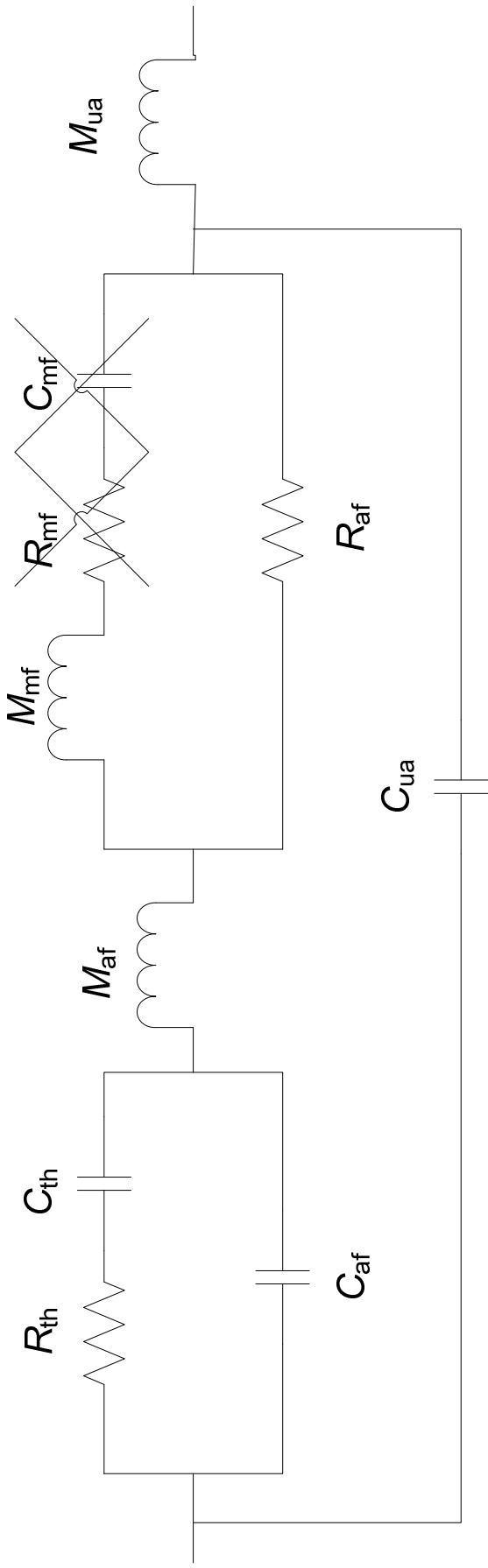
## Losses, $Q_I = 7$ : A mix of $Q_A$ and Rams





DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF

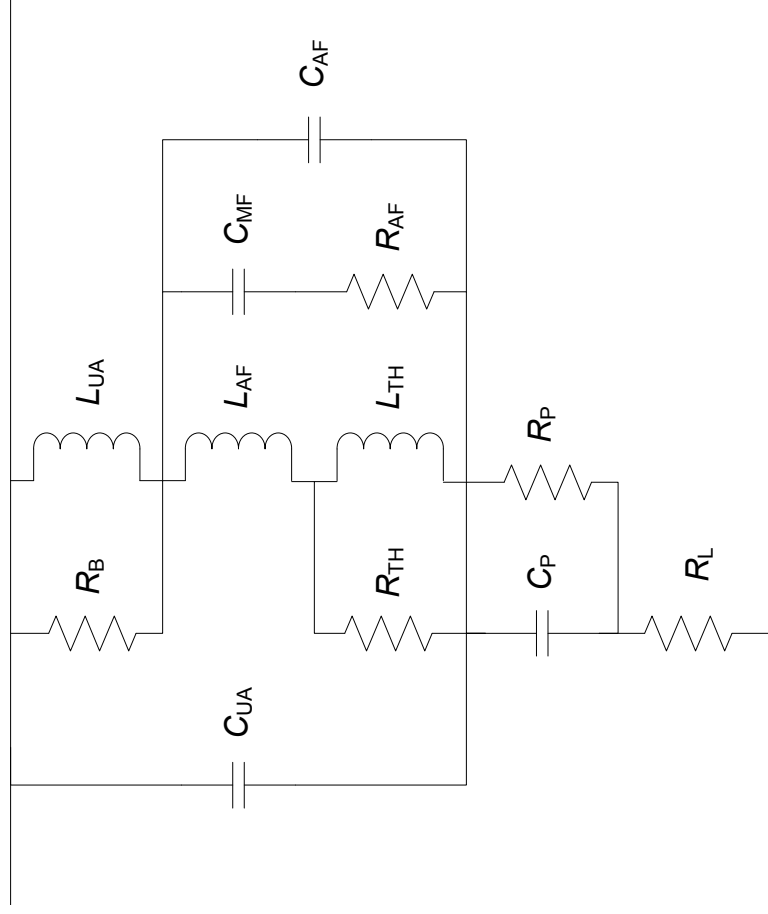
## Model of damping material





DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF

## ■ Electrical equivalent, with $R_b$

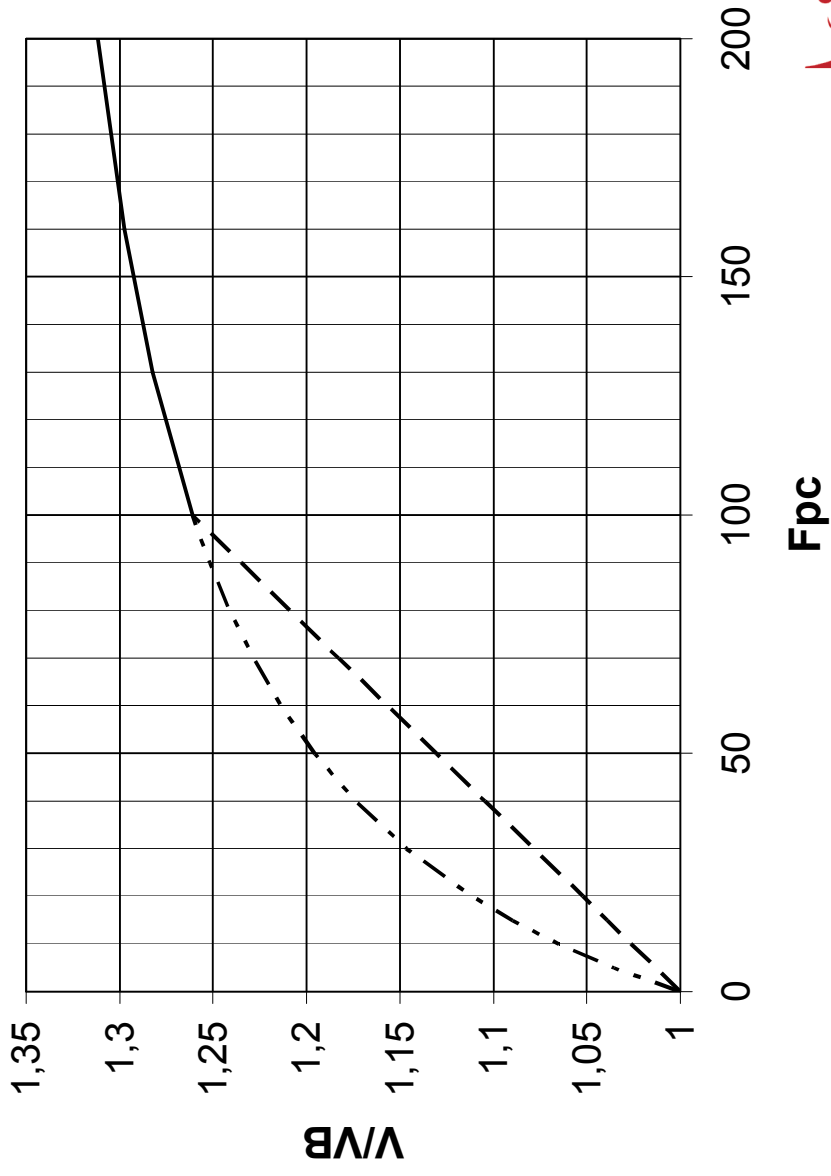






DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF

## Volume expansion graph

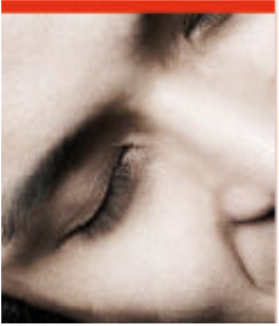




DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF

## ■ Mechanical model, Tarnow

$$\begin{aligned} R_f = \lambda &= R_{cr}^{2/3} \cdot R_{lr}^{1/3} \\ &= \frac{16 \cdot \eta}{d_f^2} \cdot \frac{f}{0,806 \cdot LN(1/f) - 0,929 + 1,26 \cdot f} \end{aligned}$$



## ■ Test box

Essentially lossless







- Our datasheets contain input to this model.
- Download free [software](#) from our web site for box simulation.
- <http://www.scan-speak.dk>
- Go to "Products"
- Go to "Toolbox"



DANISH DESIGNED AND MANUFACTURED ADVANCED PATENTED TECHNOLOGIES. COMPONENTS OF



# Thank you Questions?

Claus Futtrup

[cfu@scan-speak.dk](mailto:cfu@scan-speak.dk)