$$
\begin{array}{l}
select\ *\\
from\ LIEF\ L\\
where\ Preis <= all\ (\ select\ Preis\\
\qquad\qquad\qquad\qquad\quad from\ LIEF\\
\qquad\qquad\qquad\qquad\quad where\ Ware = L.Ware\ )
\end{array}
$$

$$
\begin{array}{l}
\mathbf{sql2tc}[\![\ select\ l1.LName, l1.LAdr, l1.Ware, l1.Preis\\
\qquad\quad from\ LIEF\ l1\\
\qquad\quad where\ l1.Preis <= all\ (\ select\ l2.Preis\\
\qquad\qquad\qquad\qquad\qquad\quad from\ LIEF\ l2\\
\qquad\qquad\qquad\qquad\qquad\quad where\ l2.Ware = l1.Ware)]\!]
\end{array}
$$

$$
\begin{array}{l}
\{r : (Res_1, Res_2, Res_3, Res_4)|\\
\quad \exists l1 : LIEF(r.Res_1 = l1.LName \wedge r.Res_2 = l1.LAdr \wedge r.Res_3 = l1.Ware \wedge r.Res_4 = l1.Preis \wedge\\
\quad \mathbf{sql2tc}[\![l1.Preis <= all\ (\ select\ l2.Preis\\
\qquad\qquad\qquad\qquad\qquad\quad from\ LIEF\ l2\\
\qquad\qquad\qquad\qquad\qquad\quad where\ l2.Ware = l1.Ware)]\!])\}
\end{array}
$$

$$
\begin{array}{l}
\{r : (Res_1, Res_2, Res_3, Res_4)|\\
\quad \exists l1 : LIEF(r.Res_1 = l1.LName \wedge r.Res_2 = l1.LAdr \wedge r.Res_3 = l1.Ware \wedge r.Res_4 = l1.Preis \wedge\\
\qquad \forall l2 : LIEF(l2.Ware = l1.Ware \Rightarrow l1.Preis <= l2.Preis))\}
\end{array}
$$

(a) τ_1 IN (SELECT τ_2 FROM ρ WHERE φ) $\Leftrightarrow$
$\tau_1 = $ ANY (SELECT τ_2 FROM ρ WHERE φ)

(b) NOT (τ_1 ω ALL (SELECT τ_2 FROM ρ WHERE φ)) $\Leftrightarrow$
τ_1 $\overline{\omega}$ ANY (SELECT τ_2 FROM ρ WHERE φ)

zu (a)

$\mathbf{sql2tc}[\![$ τ_1 IN (SELECT τ_2 FROM ρ WHERE φ) $]\!] \Leftrightarrow$
($\exists$ s_i:R_i) ((($\exists \rho_i$) $\mathbf{sql2tc}[\![\varphi]\!]$) $\wedge$ $\tau_1 = \tau_2$) $\Leftrightarrow$
$\mathbf{sql2tc}[\![$ $\tau_1 =$ ANY (SELECT τ_2 FROM ρ WHERE φ) $]\!]$

zu (b)

$\mathbf{sql2tc}[\![$ NOT (τ_1 ω ALL (SELECT τ_2 FROM ρ WHERE φ)) $]\!] \Leftrightarrow$
$\neg$ (($\forall$ s_i:R_i) (($\exists \rho_i$) $\mathbf{sql2tc}[\![\varphi]\!]$) $\Rightarrow$ $\tau_1 \omega \tau_2$) $\Leftrightarrow$
$\neg$ (($\forall$ s_i:R_i) (($\forall \rho_i$) $\neg$ $\mathbf{sql2tc}[\![\varphi]\!]$) $\vee$ $\tau_1 \omega \tau_2$) $\Leftrightarrow$
$\neg$ (($\forall$ s_i:R_i) ($\forall \rho_i$) ($\neg$ $\mathbf{sql2tc}[\![\varphi]\!] \vee \tau_1 \omega \tau_2$)) $\Leftrightarrow$
($\exists$ s_i:R_i) ($\exists \rho_i$) ($\mathbf{sql2tc}[\![\varphi]\!] \wedge \tau_1 \overline{\omega} \tau_2$) $\Leftrightarrow$
$\mathbf{sql2tc}[\![$ τ_1 $\overline{\omega}$ ANY (SELECT τ_2 FROM ρ WHERE φ) $]\!]$

Beispiel: Anwendung $\mathbf{sql2ra}[\![...]\!]$

- KUNDE(KNr,KName), BEST(KNr,Ware)
- Beispiel 1

$$\mathbf{sql2ra}[\![select\ k.KName \quad from\ KUNDE\ k, BEST\ b \quad where\ k.KNr = b.KNr\ and\ b.Ware = 42]\!] =$$

$$\pi_{k.KName}(\sigma_{k.KNr=b.KNr}(K \times B) \cap \sigma_{b.Ware=42}(K \times B))$$

$$K \times B =$$

$$\delta_{k.KNr \leftarrow KNr, k.KName \leftarrow KName}(KUNDE) \times \delta_{b.KNr \leftarrow KNr, b.Ware \leftarrow Ware}(BEST)$$

- Beispiel 2

$$\textbf{sql2ra}[\![select\ k.KName \quad from\ KUNDE\ k \quad where\ not\ \underbrace{exists\ (select\ *\ from\ BEST\ b\ where\ k.KNr = b.KNr)}_{EXISTS'}]\!] =_{(Regel\ SELECT)}$$

$$\pi_{k.KName}(\textbf{sql2ra}[\![not\ EXISTS']\!](\underbrace{rename[\![KUNDE\ k]\!]}_{KUNDE'=\delta_{k.KNr\leftarrow KNr,k.KName\leftarrow KName}(KUNDE)})) =_{(Regel\ NOT)}$$

$$\pi_{k.KName}(\textbf{sql2ra-}[\![EXISTS']\!](KUNDE')) =_{(Regel\ \textbf{sql2ra-})}$$

$$\pi_{k.KName}(KUNDE' - \pi_{k.KNr,k.KName}(\textbf{sql2ra}[\![EXISTS']\!](KUNDE'))) =_{(Regel\ EXISTS)}$$

$$\pi_{k.KName}(KUNDE' - \pi_{k.KNr,k.KName}(\textbf{sql2ra}[\![k.KNr = b.KNr]\!](KUNDE' \times \underbrace{rename[\![BEST\ b]\!]}_{BEST'=\delta_{b.KNr\leftarrow KNr,b.Ware\leftarrow Ware}(BEST)}))) =_{(Regel\ \tau_1\ \omega\ \tau_2)}$$

$$\pi_{k.KName}(KUNDE' - \pi_{k.KNr,k.KName}(\sigma_{k.KNr=b.KNr}(KUNDE' \times BEST')))$$