MPG No. 10.1.32 $\bar{4}$ [Type I, tetragonal] [M tensor]

* Rank 0 tensor. * Rank 1 tensor.

$$\begin{bmatrix} 0 & 0 & M_z \end{bmatrix}$$

$$M_z = M_{pz}^{(1)}$$

* Rank 2 tensor (s).

$$\begin{bmatrix} M_{xx} & M_{xy} & 0 \\ M_{xy} & -M_{xx} & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$M_{xx} = M_{dv}^{(1)}$$
$$M_{xy} = M_{dxy}^{(1)}$$

* Rank 2 tensor (a). * Rank 3 tensor (s).

$$\begin{bmatrix} 0 & 0 & M_{xxz} \\ 0 & 0 & M_{xxz} \\ 0 & 0 & M_{zzz} \\ M_{yzx} & M_{yzy} & 0 \\ M_{yzy} & -M_{yzx} & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$M_{xxz} = -M_{faz}^{(1)} + M_{pz}^{(1)}$$
$$M_{zzz} = 2M_{faz}^{(1)} + M_{pz}^{(1)} + 2M_{pz}^{(2)}$$
$$M_{yzx} = -3T_{du}^{(1)}$$
$$M_{yzy} = -M_{faz}^{(1)} + M_{pz}^{(2)}$$

* Rank 3 tensor (a).

$$\begin{bmatrix} M_{yzx} & M_{yzy} & 0 \\ -M_{yzy} & M_{yzx} & 0 \\ 0 & 0 & M_{xyz} \end{bmatrix}$$

$$M_{yzx} = -T_{du}^{(2)} + T_s^{(1)}$$
$$M_{yzy} = M_{pz}^{(3)}$$
$$M_{xyz} = 2T_{du}^{(2)} + T_s^{(1)}$$

* Rank 4 tensor (sss).

$$\begin{bmatrix} M_{xxxx} & 0 & M_{xxzz} & 0 & 0 & M_{xxxy} \\ 0 & -M_{xxxx} & -M_{xxzz} & 0 & 0 & M_{xxxy} \\ M_{xxzz} & -M_{xxzz} & 0 & 0 & 0 & M_{zzxy} \\ 0 & 0 & 0 & M_{yzyz} & M_{yzzx} & 0 \\ 0 & 0 & 0 & M_{yzzx} & -M_{yzyz} & 0 \\ M_{xxxy} & M_{xxxy} & M_{zzxy} & 0 & 0 & 0 \end{bmatrix}$$

$$M_{xxxx} = 2M_{dv}^{(1)} + 4M_{dv}^{(2)} + M_{gv}^{(1)}$$
$$M_{xxzz} = M_{dv}^{(1)} - M_{gv}^{(1)}$$
$$M_{xxxy} = M_{dxy}^{(1)} + 2M_{dxy}^{(2)} - M_{gbz}^{(1)}$$
$$M_{zzxy} = M_{dxy}^{(1)} + 2M_{gbz}^{(1)}$$
$$M_{yzyz} = -M_{dv}^{(2)} + M_{gv}^{(1)}$$
$$M_{yzzx} = M_{dxy}^{(2)} + 2M_{gbz}^{(1)}$$

* Rank 4 tensor (ssa).

$$\begin{bmatrix} 0 & M_{xxyy} & M_{xxzz} & 0 & 0 & M_{xxxy} \\ -M_{xxyy} & 0 & -M_{xxzz} & 0 & 0 & M_{xxxy} \\ -M_{xxzz} & M_{xxzz} & 0 & 0 & 0 & M_{zzxy} \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -M_{xxxy} & -M_{xxxy} & -M_{zzxy} & 0 & 0 & 0 \end{bmatrix}$$

$$M_{xxyy} = -2M_{dv}^{(3)} + 4T_{f3}^{(1)}$$
$$M_{xxzz} = -M_{dv}^{(3)} - 4T_{f3}^{(1)}$$
$$M_{xxxy} = M_{dxy}^{(3)} + 2T_{fbz}^{(1)}$$
$$M_{zzxy} = M_{dxy}^{(3)} - 4T_{fbz}^{(1)}$$

* Rank 4 tensor (aas).

$$\begin{bmatrix} M_{yzyz} & M_{yzzx} & 0 \\ M_{yzzx} & -M_{yzyz} & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$M_{yzyz} = 2M_{dv}^{(4)}$$
$$M_{yzzx} = 2M_{dxy}^{(4)}$$

* Rank 4 tensor (aaa). * Rank 4 tensor (sa).

$$\begin{bmatrix} 0 & 0 & M_{xxxy} \\ 0 & 0 & -M_{xxxy} \\ 0 & 0 & 0 \\ M_{yzyz} & M_{yzzx} & 0 \\ -M_{yzzx} & M_{yzyz} & 0 \\ 0 & 0 & M_{xyxy} \end{bmatrix}$$

$$M_{xxxy} = -2M_{dxy}^{(5)} + T_{fbz}^{(2)}$$
$$M_{yzyz} = -M_{dv}^{(5)} + T_{f3}^{(2)}$$
$$M_{yzzx} = -M_{dxy}^{(5)} - T_{fbz}^{(2)}$$
$$M_{xyxy} = 2M_{dv}^{(5)} + T_{f3}^{(2)}$$

* Rank 4 tensor (as).

$$\begin{bmatrix} 0 & 0 & 0 & M_{yzyz} & M_{yzzx} & 0 \\ 0 & 0 & 0 & -M_{yzzx} & M_{yzyz} & 0 \\ M_{xyxx} & -M_{xyxx} & 0 & 0 & 0 & M_{xyxy} \end{bmatrix}$$

$$M_{yzyz} = -M_{dv}^{(6)} + T_{f3}^{(3)}$$
$$M_{yzzx} = M_{dxy}^{(6)} + T_{fbz}^{(3)}$$
$$M_{xyxx} = -2M_{dxy}^{(6)} + T_{fbz}^{(3)}$$
$$M_{xyxy} = 2M_{dv}^{(6)} + T_{f3}^{(3)}$$

* Rank 4 tensor (s).

$$\begin{bmatrix} M_{xxxx} & M_{xxyy} & M_{xxzz} & 0 & 0 & M_{xxxy} & 0 & 0 & M_{xxyx} \\ -M_{xxyy} & -M_{xxxx} & -M_{xxzz} & 0 & 0 & M_{xxyx} & 0 & 0 & M_{xxxy} \\ M_{zzxx} & -M_{zzxx} & 0 & 0 & 0 & M_{zzxy} & 0 & 0 & M_{zzxy} \\ 0 & 0 & 0 & M_{yzyz} & M_{yzzx} & 0 & M_{yzzy} & M_{yzxz} & 0 \\ 0 & 0 & 0 & M_{yzxz} & -M_{yzzy} & 0 & M_{yzzx} & -M_{yzyz} & 0 \\ M_{xyxx} & M_{xyxx} & M_{xyzz} & 0 & 0 & M_{xyxy} & 0 & 0 & -M_{xyxy} \end{bmatrix}$$

$$M_{xxxx} = 2M_{dv}^{(1)} + 4M_{dv}^{(2)} + M_{gv}^{(1)}$$
$$M_{xxyy} = -2M_{dv}^{(3)} + 4T_{f3}^{(1)}$$
$$M_{xxzz} = M_{dv}^{(1)} - M_{dv}^{(3)} - M_{gv}^{(1)} - 4T_{f3}^{(1)}$$
$$M_{xxxy} = M_{dxy}^{(1)} + 2M_{dxy}^{(2)} + M_{dxy}^{(3)} - 2M_{dxy}^{(5)} - M_{gbz}^{(1)} + 2T_{fbz}^{(1)} + T_{fbz}^{(2)}$$
$$M_{xxyx} = M_{dxy}^{(1)} + 2M_{dxy}^{(2)} + M_{dxy}^{(3)} + 2M_{dxy}^{(5)} - M_{gbz}^{(1)} + 2T_{fbz}^{(1)} - T_{fbz}^{(2)}$$
$$M_{zzxx} = M_{dv}^{(1)} + M_{dv}^{(3)} - M_{gv}^{(1)} + 4T_{f3}^{(1)}$$
$$M_{zzxy} = M_{dxy}^{(1)} + M_{dxy}^{(3)} + 2M_{gbz}^{(1)} - 4T_{fbz}^{(1)}$$
$$M_{yzyz} = -M_{dv}^{(2)} - M_{dv}^{(5)} + M_{gv}^{(1)} + T_{f3}^{(2)}$$
$$M_{yzzx} = M_{dxy}^{(2)} - M_{dxy}^{(5)} + 2M_{gbz}^{(1)} - T_{fbz}^{(2)}$$
$$M_{yzzy} = -M_{dv}^{(2)} + M_{dv}^{(5)} + M_{gv}^{(1)} - T_{f3}^{(2)}$$
$$M_{yzxz} = M_{dxy}^{(2)} + M_{dxy}^{(5)} + 2M_{gbz}^{(1)} + T_{fbz}^{(2)}$$
$$M_{xyxx} = M_{dxy}^{(1)} + 2M_{dxy}^{(2)} - M_{dxy}^{(3)} - M_{gbz}^{(1)} - 2T_{fbz}^{(1)}$$
$$M_{xyzz} = M_{dxy}^{(1)} - M_{dxy}^{(3)} + 2M_{gbz}^{(1)} + 4T_{fbz}^{(1)}$$
$$M_{xyxy} = 2M_{dv}^{(5)} + T_{f3}^{(2)}$$

* Rank 4 tensor (a).

$$\begin{bmatrix} 0 & 0 & 0 & M_{yzyz} & M_{yzzx} & 0 & M_{yzzy} & M_{yzxz} & 0 \\ 0 & 0 & 0 & -M_{yzxz} & M_{yzzy} & 0 & -M_{yzzx} & M_{yzyz} & 0 \\ M_{xyxx} & -M_{xyxx} & 0 & 0 & 0 & M_{xyxy} & 0 & 0 & M_{xyxy} \end{bmatrix}$$

$$M_{yzyz} = 2M_{dv}^{(4)} - M_{dv}^{(6)} + T_{f3}^{(3)}$$
$$M_{yzzx} = 2M_{dxy}^{(4)} + M_{dxy}^{(6)} + T_{fbz}^{(3)}$$
$$M_{yzzy} = -2M_{dv}^{(4)} - M_{dv}^{(6)} + T_{f3}^{(3)}$$
$$M_{yzxz} = -2M_{dxy}^{(4)} + M_{dxy}^{(6)} + T_{fbz}^{(3)}$$
$$M_{xyxx} = -2M_{dxy}^{(6)} + T_{fbz}^{(3)}$$
$$M_{xyxy} = 2M_{dv}^{(6)} + T_{f3}^{(3)}$$

* Rank 4 tensor (t).

$$\begin{bmatrix} M_{xxxx} & M_{xxxy} & 0 \\ M_{xxxy} & -M_{xxxx} & 0 \\ 0 & 0 & 0 \\ 0 & 0 & M_{yyzz} \\ M_{zzxx} & M_{zzxy} & 0 \\ M_{xxyx} & -M_{yyzz} - M_{zzxx} & 0 \\ M_{yzzx} & M_{yzzy} & 0 \\ 0 & 0 & M_{zxxz} \\ -M_{yzzy} - M_{zxxz} & M_{xyyy} & 0 \\ 0 & 0 & -\frac{M_{xxxy}}{2} - \frac{M_{xxyx}}{2} + M_{xyyy} + M_{zzxy} \end{bmatrix}$$

$$
\begin{aligned}
M_{xxxx} &= 2M_{dv}^{(1)} + 4M_{dv}^{(2)} + M_{gv}^{(1)} \\
M_{xxxy} &= M_{dxy}^{(1)} + 2M_{dxy}^{(2)} + M_{dxy}^{(3)} - 2M_{dxy}^{(5)} - M_{gbz}^{(1)} \\
M_{yyzz} &= -M_{dv}^{(1)} + M_{dv}^{(3)} + M_{gv}^{(1)} \\
M_{zzxx} &= M_{dv}^{(1)} + M_{dv}^{(3)} - M_{gv}^{(1)} \\
M_{zzxy} &= M_{dxy}^{(1)} + M_{dxy}^{(3)} + 2M_{gbz}^{(1)} \\
M_{xxyx} &= M_{dxy}^{(1)} + 2M_{dxy}^{(2)} + M_{dxy}^{(3)} + 2M_{dxy}^{(5)} - M_{gbz}^{(1)} \\
M_{yzzx} &= M_{dxy}^{(2)} - M_{dxy}^{(5)} + 2M_{gbz}^{(1)} \\
M_{yzzy} &= -M_{dv}^{(2)} + M_{dv}^{(5)} + M_{gv}^{(1)} \\
M_{zxxz} &= M_{dv}^{(2)} + M_{dv}^{(5)} - M_{gv}^{(1)} \\
M_{xyyy} &= M_{dxy}^{(1)} + 2M_{dxy}^{(2)} - M_{dxy}^{(3)} - M_{gbz}^{(1)}
\end{aligned}
$$