

# NAG Library Function Document

## nag\_opt\_handle\_set\_linconstr (e04rjc)

### 1 Purpose

nag\_opt\_handle\_set\_linconstr (e04rjc) is a part of the NAG optimization modelling suite and defines the block of linear constraints of the problem.

### 2 Specification

```
#include <nag.h>
#include <nage04.h>

void nag_opt_handle_set_linconstr (void *handle, Integer nclin,
    const double bl[], const double bu[], Integer nnzb,
    const Integer irowb[], const Integer icolb[], const double b[],
    Integer *idlc, NagError *fail)
```

### 3 Description

After the initialization function nag\_opt\_handle\_init (e04rac) has been called, nag\_opt\_handle\_set\_linconstr (e04rjc) may be used to define the linear constraints  $l_B \leq Bx \leq u_B$  of the problem unless the linear constraints have already been defined. This will typically be used for problems, such as quadratic programming (QP)

$$\begin{aligned} & \underset{x \in \mathbb{R}^n}{\text{minimize}} && \frac{1}{2}x^T Hx + c^T x && (a) \\ & \text{subject to} && l_B \leq Bx \leq u_B && (b) \\ & && l_x \leq x \leq u_x, && (c) \end{aligned} \quad (1)$$

nonlinear programming (NLP)

$$\begin{aligned} & \underset{x \in \mathbb{R}^n}{\text{minimize}} && f(x) && (a) \\ & \text{subject to} && l_g \leq g(x) \leq u_g && (b) \\ & && l_B \leq Bx \leq u_B && (c) \\ & && l_x \leq x \leq u_x && (d) \end{aligned} \quad (2)$$

linear semidefinite programming (SDP)

$$\begin{aligned} & \underset{x \in \mathbb{R}^n}{\text{minimize}} && c^T x && (a) \\ & \text{subject to} && \sum_{i=1}^n x_i A_i^k - A_0^k \succeq 0, \quad k = 1, \dots, m_A && (b) \\ & && l_B \leq Bx \leq u_B && (c) \\ & && l_x \leq x \leq u_x && (d) \end{aligned} \quad (3)$$

or semidefinite programming with bilinear matrix inequalities (BMI-SDP)

$$\begin{aligned} & \underset{x \in \mathbb{R}^n}{\text{minimize}} && \frac{1}{2}x^T Hx + c^T x && (a) \\ & \text{subject to} && \sum_{i,j=1}^n x_i x_j Q_{ij}^k + \sum_{i=1}^n x_i A_i^k - A_0^k \succeq 0, \quad k = 1, \dots, m_A && (b) \\ & && l_B \leq Bx \leq u_B && (c) \\ & && l_x \leq x \leq u_x && (d) \end{aligned} \quad (4)$$

where  $n$  is the number of decision variables,  $B$  is a general  $m_B \times n$  rectangular matrix and  $l_B$  and  $u_B$  are  $m_B$ -dimensional vectors. Note that upper and lower bounds are specified for all the constraints. This form allows full generality in specifying various types of constraint. In particular, the  $j$ th constraint may be defined as an equality by setting  $l_j = u_j$ . If certain bounds are not present, the associated elements of

$l_B$  or  $u_B$  may be set to special values that are treated as  $-\infty$  or  $+\infty$ . See the description of the optional parameter **Infinite Bound Size** of the solvers in the suite, `nag_opt_handle_solve_ipopt` (e04stc) and `nag_opt_handle_solve_pennon` (e04svc). Its value is denoted as *bigbnd* further in this text. Note that the bounds are interpreted based on its value at the time of calling this function and any later alterations to **Infinite Bound Size** will not affect these constraints.

See `nag_opt_handle_init` (e04rac) for more details.

## 4 References

None.

## 5 Arguments

1: **handle** – void \* *Input*

*On entry:* the handle to the problem. It needs to be initialized by `nag_opt_handle_init` (e04rac) and **must not** be changed.

2: **nclin** – Integer *Input*

*On entry:*  $m_B$ , the number of linear constraints (number of rows of the matrix  $B$ ).

If **nclin** = 0, no linear constraints will be defined and **bl**, **bu**, **nnzb**, **irowb**, **icolb** and **b** will not be referenced and may be **NULL**.

*Constraint:* **nclin**  $\geq 0$ .

3: **bl[nclin]** – const double *Input*

4: **bu[nclin]** – const double *Input*

*On entry:* **bl** and **bu** define lower and upper bounds of the linear constraints,  $l_B$  and  $u_B$ , respectively. To define the  $j$ th constraint as equality, set **bl**[ $j-1$ ] = **bu**[ $j-1$ ] =  $\beta$ , where  $|\beta| < \text{bigbnd}$ . To specify a nonexistent lower bound (i.e.,  $l_j = -\infty$ ), set **bl**[ $j-1$ ]  $\leq -\text{bigbnd}$ ; to specify a nonexistent upper bound, set **bu**[ $j-1$ ]  $\geq \text{bigbnd}$ .

*Constraints:*

**bl**[ $j-1$ ]  $\leq$  **bu**[ $j-1$ ], for  $j = 1, 2, \dots, \text{nclin}$ ;  
**bl**[ $j-1$ ]  $< \text{bigbnd}$ , for  $j = 1, 2, \dots, \text{nclin}$ ;  
**bu**[ $j-1$ ]  $> -\text{bigbnd}$ , for  $j = 1, 2, \dots, \text{nclin}$ ;  
if **bl**[ $j-1$ ] = **bu**[ $j-1$ ], **bl**[ $j-1$ ]  $< \text{bigbnd}$ , for  $j = 1, 2, \dots, \text{nclin}$ .

5: **nnzb** – Integer *Input*

*On entry:* **nnzb** gives the number of nonzeros in matrix  $B$ .

*Constraint:* if **nclin**  $> 0$ , **nnzb**  $> 0$ .

6: **irowb[nnzb]** – const Integer *Input*

7: **icolb[nnzb]** – const Integer *Input*

8: **b[nnzb]** – const double *Input*

*On entry:* arrays **irowb**, **icolb** and **b** store **nnzb** nonzeros of the sparse matrix  $B$  in coordinate storage (CS) format (see Section 2.1.1 in the f11 Chapter Introduction). The matrix  $B$  has dimensions  $m_B \times n$ , where  $n$ , the number of variables in the problem, was set in **nvar** during the initialization of the handle by `nag_opt_handle_init` (e04rac). **irowb** specifies one-based row indices, **icolb** specifies one-based column indices and **b** specifies the values of the nonzero elements in such a way that  $b_{ij} = \mathbf{b}[l-1]$  where  $i = \mathbf{irowb}[l-1]$  and  $j = \mathbf{icolb}[l-1]$ , for  $l = 1, 2, \dots, \text{nnzb}$ . No particular order of elements is expected, but elements should not repeat.

*Constraint:*  $1 \leq \mathbf{irowb}[l-1] \leq \text{nclin}$ ,  $1 \leq \mathbf{icolb}[l-1] \leq n$ , for  $l = 1, 2, \dots, \text{nnzb}$ .

9: **idlc** – Integer \*

*Input/Output*

**Note:** **idlc** is reserved for future releases of the NAG C Library.

*On entry:* if **idlc** = 0, new linear constraints are added to the problem definition. This is the only value allowed at the moment.

*Constraint:* **idlc** = 0.

*On exit:* the number of the last linear constraint added, thus **nclin**.

10: **fail** – NagError \*

*Input/Output*

The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

## 6 Error Indicators and Warnings

### NE\_ALLOC\_FAIL

Dynamic memory allocation failed.

See Section 2.3.1.2 in How to Use the NAG Library and its Documentation for further information.

### NE\_ALREADY\_DEFINED

A set of linear constraints has already been defined.

### NE\_BAD\_PARAM

On entry, argument  $\langle value \rangle$  had an illegal value.

### NE\_BOUND

On entry,  $j = \langle value \rangle$ ,  $\mathbf{bl}[j - 1] = \langle value \rangle$ ,  $\mathbf{bigbnd} = \langle value \rangle$ .

Constraint:  $\mathbf{bl}[j - 1] < \mathbf{bigbnd}$ .

On entry,  $j = \langle value \rangle$ ,  $\mathbf{bl}[j - 1] = \langle value \rangle$  and  $\mathbf{bu}[j - 1] = \langle value \rangle$ .

Constraint:  $\mathbf{bl}[j - 1] \leq \mathbf{bu}[j - 1]$ .

On entry,  $j = \langle value \rangle$ ,  $\mathbf{bu}[j - 1] = \langle value \rangle$ ,  $\mathbf{bigbnd} = \langle value \rangle$ .

Constraint:  $\mathbf{bu}[j - 1] > -\mathbf{bigbnd}$ .

### NE\_HANDLE

The supplied **handle** does not define a valid handle to the data structure for the NAG optimization modelling suite. It has not been initialized by `nag_opt_handle_init` (e04rac) or it has been corrupted.

### NE\_INT

On entry, **nclin** =  $\langle value \rangle$ .

Constraint: **nclin**  $\geq 0$ .

On entry, **nnzb** =  $\langle value \rangle$ .

Constraint: **nnzb**  $> 0$ .

### NE\_INTERNAL\_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

An unexpected error has been triggered by this function. Please contact NAG.

See Section 2.7.6 in How to Use the NAG Library and its Documentation for further information.

**NE\_INVALID\_CS**

On entry,  $i = \langle value \rangle$ ,  $\mathbf{icolb}[i - 1] = \langle value \rangle$  and  $n = \langle value \rangle$ .

Constraint:  $1 \leq \mathbf{icolb}[i - 1] \leq n$ .

On entry,  $i = \langle value \rangle$ ,  $\mathbf{irowb}[i - 1] = \langle value \rangle$  and  $\mathbf{nclin} = \langle value \rangle$ .

Constraint:  $1 \leq \mathbf{irowb}[i - 1] \leq \mathbf{nclin}$ .

On entry, more than one element of  $\mathbf{b}$  has row index  $\langle value \rangle$  and column index  $\langle value \rangle$ .

Constraint: each element of  $\mathbf{b}$  must have a unique row and column index.

**NE\_NO\_LICENCE**

Your licence key may have expired or may not have been installed correctly.

See Section 2.7.5 in How to Use the NAG Library and its Documentation for further information.

**NE\_PHASE**

The problem cannot be modified in this phase any more, the solver has already been called.

**NE\_REF\_MATCH**

On entry,  $\mathbf{idlc} = \langle value \rangle$ .

Constraint:  $\mathbf{idlc} = 0$ .

**7 Accuracy**

Not applicable.

**8 Parallelism and Performance**

`nag_opt_handle_set_linconstr` (e04rjc) is not threaded in any implementation.

**9 Further Comments**

None.

**10 Example**

This example demonstrates how to use the MPS file reader `nag_opt_miqp_mps_read` (e04mxc) and this suite of functions to define and solve a QP problem. `nag_opt_miqp_mps_read` (e04mxc) uses a different output format to the one required by `nag_opt_handle_set_linconstr` (e04rjc), in particular, it uses the compressed column storage (CCS) (see Section 2.1.3 in the f11 Chapter Introduction) instead of the coordinate storage and the linear objective vector is included in the system matrix. Therefore a simple transformation is needed before calling `nag_opt_handle_set_linconstr` (e04rjc) as demonstrated in the example program.

The data file stores the following problem:

$$\text{minimize } c^T x + \frac{1}{2} x^T H x \quad \text{subject to} \quad \begin{array}{l} l_B \leq Bx \leq u_B, \\ -2 \leq x \leq 2, \end{array}$$

where

$$c = \begin{pmatrix} -4.0 \\ -1.0 \\ -1.0 \\ -1.0 \\ -1.0 \\ -1.0 \\ -1.0 \\ -0.1 \\ -0.3 \end{pmatrix}, \quad H = \begin{pmatrix} 2 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 2 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 2 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 2 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix},$$

$$B = \begin{pmatrix} 1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 4.0 \\ 1.0 & 2.0 & 3.0 & 4.0 & -2.0 & 1.0 & 1.0 & 1.0 & 1.0 \\ 1.0 & -1.0 & 1.0 & -1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1.0 \end{pmatrix},$$

$$l_B = \begin{pmatrix} -2.0 \\ -2.0 \\ -2.0 \end{pmatrix} \quad \text{and} \quad u_B = \begin{pmatrix} 1.5 \\ 1.5 \\ 4.0 \end{pmatrix}.$$

The optimal solution (to five figures) is

$$x^* = (2.0, -0.23333, -0.26667, -0.3, -0.1, 2.0, 2.0, -1.7777, -0.45555)^T.$$

See also Section 10 in `nag_opt_handle_init` (e04rac) for links to further examples in this suite.

## 10.1 Program Text

```

/* nag_opt_handle_set_linconstr (e04rjc) Example Program.
*
* NAGPRODCODE Version.
*
* Copyright 2016 Numerical Algorithms Group.
*
* Mark 26, 2016.
*/

/* Read in LP/QP problem stored in a MPS file, formulated it
* as a handle and pass it to the solver.
*/
#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nage04.h>
#include <nagx04.h>

/* Make a typedef for convenience when allocating crname. */
typedef char e04mx_name[9];

int main(int argc, char *argv[])
{
    char fname_default[] = "e04rjce.opt";
    Integer mpslst = 1;

    Integer exit_status = 0;
    Integer idlc, idx, idx_dest, inform, iobj, j, lintvar, m, maxlintvar,
        maxm, maxn, maxncolh, maxnnz, maxnnzh, minmax, n, ncolh, nname,
        nnz, nnzc, nnzh, nnzu, nnzua, nnzuc;
    char *fname = 0;
    char pnames[5][9] = { "", "", "", "", "" };
    double rinfo[32], stats[32];
    double *a = 0, *bl = 0, *bu = 0, *c = 0, *h = 0, *x = 0;
    Integer *iccola = 0, *iccolh = 0, *icola = 0, *icolh = 0, *idxc = 0,
        *irowa = 0, *irowh = 0;
    char (*crname)[9] = 0;
    void *handle = 0;
    /* Nag Types */
    Nag_FileID fileid;

```

```

NagError fail;

printf("nag_opt_handle_set_linconstr (e04rjc) Example Program Results\n\n");

/* Use the first command line argument as the filename or
 * choose default filename stored in 'fname_default'. */
if (argc > 1)
    fname = argv[1];
else
    fname = fname_default;
printf("Reading MPS file: %s\n", fname);
fflush(stdout);

/* nag_open_file (x04acc).
 * Open unit number for reading and associate unit with named file. */
nag_open_file(fname, 0, &fileid, NAGERR_DEFAULT);

/* nag_opt_miqp_mps_read (e04mxc).
 * Reads MPS data file defining LP or QP problem.
 * Query call to estimate the size of the problem. */
nag_opt_miqp_mps_read(fileid, 0, 0, 0, 0, 0, 0, mpslst, &n, &m, &nnz,
                      &ncolh, &nnzh, &lintvar, NULL, NULL, NULL, NULL, NULL,
                      NULL, NULL, NULL, NULL, NULL, NULL, NULL, NULL, NULL,
                      NAGERR_DEFAULT);

/* nag_close_file (x04adc).
 * Close file associated with given unit number. */
nag_close_file(fileid, NAGERR_DEFAULT);

maxm = m;
maxn = n;
maxnnz = nnz;
maxnnzh = nnzh;
maxncolh = ncolh;
maxlintvar = -1;

if (!(irowa = NAG_ALLOC(maxnnz, Integer)) ||
    !(iccola = NAG_ALLOC(maxn + 1, Integer)) ||
    !(a = NAG_ALLOC(maxnnz, double)) ||
    !(bl = NAG_ALLOC(maxn + maxm, double)) ||
    !(bu = NAG_ALLOC(maxn + maxm, double)) ||
    !(irowh = NAG_ALLOC(maxnnzh, Integer)) ||
    !(icolh = NAG_ALLOC(maxncolh + 1, Integer)) ||
    !(h = NAG_ALLOC(maxnnzh, double)) ||
    !(cname = NAG_ALLOC(maxn + maxm, e04mx_name)) ||
    !(x = NAG_ALLOC(maxn, double)) ||
    !(icolh = NAG_ALLOC(maxnnzh, Integer)) ||
    !(icola = NAG_ALLOC(maxnnz, Integer)))
{
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
}

/* Reopen the same file. */
nag_open_file(fname, 0, &fileid, NAGERR_DEFAULT);

/* Full call to the reader. */
nag_opt_miqp_mps_read(fileid, maxn, maxm, maxnnz, maxncolh, maxnnzh,
                      maxlintvar, mpslst, &n, &m, &nnz, &ncolh, &nnzh,
                      &lintvar, &iobj, a, irowa, iccola, bl, bu, pnames,
                      &name, cname, h, irowh, iccolh, &minmax, NULL,
                      NAGERR_DEFAULT);

nag_close_file(fileid, NAGERR_DEFAULT);

printf("MPS/QPS file read.\n");
fflush(stdout);

/* Data has been read. Set up the problem to the solver. */

```

```

/* nag_opt_handle_init (e04rac).
 * Initialize an empty problem handle with n variables. */
nag_opt_handle_init(&handle, n, NAGERR_DEFAULT);

/* iccola[] was returned as 1-based, i.e., iccola[0]=1.
 * Change it to 0-based to simplify C operations. */
for (j = 0; j <= n; j++)
    iccola[j]--;

/* Move the linear objective from a to c. */
if (iobj > 0) {
    /* Shift bounds. */
    for (j = n + iobj - 1; j < n + m - 1; j++) {
        bl[j] = bl[j + 1];
        bu[j] = bu[j + 1];
    }
    m--;

    /* Count how many nonzeros will be in c. */
    nnzc = 0;
    for (idx = 0; idx < nnz; idx++)
        if (irowa[idx] == iobj)
            nnzc++;

    if (!(idxc = NAG_ALLOC(nnzc, Integer)) || !(c = NAG_ALLOC(nnzc, double)))
    {
        printf("Allocation failure\n");
        exit_status = -1;
        goto END;
    }

    /* Extract row iobj form column compressed matrix a. */
    idx = 0;
    idx_dest = 0;
    nnzc = 0;
    for (j = 0; j < n; j++) {
        for (; idx < iccola[j + 1]; idx++) {
            if (irowa[idx] < iobj) {
                a[idx_dest] = a[idx];
                irowa[idx_dest] = irowa[idx];
                idx_dest++;
            }
            else if (irowa[idx] == iobj) {
                idxc[nnzc] = j + 1;
                c[nnzc] = a[idx];
                nnzc++;
            }
            else {
                a[idx_dest] = a[idx];
                irowa[idx_dest] = irowa[idx] - 1;
                idx_dest++;
            }
        }
        iccola[j + 1] = idx_dest;
    }
    nnz = idx_dest;
}
else
    /* There is no linear part of the objective function. */
    nnzc = 0;

/* Convert (decompress) iccola[] to icola[]. */
for (j = 0; j < n; j++)
    for (idx = iccola[j]; idx < iccola[j + 1]; idx++)
        icola[idx] = j + 1;

/* Add objective function to the problem formulation. */
if (nnzh == 0)
    /* nag_opt_handle_set_quadobj (e04rjc).
     * Define the objective as a (sparse) linear function (no nonzeros in H). */
    nag_opt_handle_set_quadobj(handle, nnzc, idxc, c, 0, NULL, NULL, NULL,

```

```

                                NAGERR_DEFAULT);
else {
    /* The objective is a quadratic function.
     * Firstly, transform (decompress) iccolh[] to icolh[], both are 1-based.
     * Secondly, e04mxc() returned a lower triangle but here
     * the upper triangle is needed ==> swap rows and columns. */
    for (j = 0; j < ncolh; j++)
        for (idx = iccolh[j]; idx < iccolh[j + 1]; idx++)
            icolh[idx - 1] = j + 1;
    /* nag_opt_handle_set_quadobj (e04rjc).
     * Add the quadratic objective to the handle.*/
    nag_opt_handle_set_quadobj(handle, nnzc, idxc, c, nnzh, icolh, irowh, h,
                                NAGERR_DEFAULT);
}

/* nag_opt_handle_set_simplebounds (e04rhc).
 * Define bounds on the variables. */
nag_opt_handle_set_simplebounds(handle, n, bl, bu, NAGERR_DEFAULT);

idlc = 0;
/* nag_opt_handle_set_linconstr (e04rjc).
 * Add a block of linear constraints to the problem formulation.
 * Bounds of the constraints are stored after bounds on the variables. */
nag_opt_handle_set_linconstr(handle, m, bl + n, bu + n, nnz, irowa, icola,
                              a, &idlc, NAGERR_DEFAULT);

printf("The problem was set-up\n");
fflush(stdout);

/* Set optional arguments of the solver by calling
 * nag_opt_handle_opt_set (e04zmc). */
nag_opt_handle_opt_set(handle, "Print Options = No", NAGERR_DEFAULT);

/* Set up a starting point and call the solver,
 * ignore Lagrangian multipliers U/UA. */
for (j = 0; j < n; j++)
    x[j] = 0.0;
nnzu = 0;
nnzuc = 0;
nnzua = 0;

/* Call the solver nag_opt_handle_solve_pennon (e04svc). */
INIT_FAIL(fail);
nag_opt_handle_solve_pennon(handle, n, x, nnzu, NULL, nnzuc, NULL, nnzua,
                             NULL, rinfo, stats, &inform, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_opt_handle_solve_pennon (e04svc).\n%s\n",
           fail.message);
    exit_status = 1;
    goto END;
}

printf("\nOptimal solution:\n");
for (j = 0; j < n; j++)
    printf("  %f\n", x[j]);
fflush(stdout);

END:

/* nag_opt_handle_free (e04rzc).
 * Destroy the problem handle and deallocate all the memory. */
if (handle)
    nag_opt_handle_free(&handle, NAGERR_DEFAULT);

NAG_FREE(a);
NAG_FREE(bl);
NAG_FREE(bu);
NAG_FREE(idxc);
NAG_FREE(c);
NAG_FREE(h);
NAG_FREE(x);

```



```

NAG_FREE(iccola);
NAG_FREE(iccolh);
NAG_FREE(icola);
NAG_FREE(icolh);
NAG_FREE(irowa);
NAG_FREE(irowh);
NAG_FREE(crname);
return exit_status;
}

```

## 10.2 Program Data

```

NAME                E04RJ.EX
ROWS
  L  ..ROW1..
  L  ..ROW2..
  L  ..ROW3..
  N  ..COST..
COLUMNS
  ...X1...  ..ROW1..      1.0      ..ROW2..      1.0
  ...X1...  ..ROW3..      1.0      ..COST..      -4.0
  ...X2...  ..ROW1..      1.0      ..ROW2..      2.0
  ...X2...  ..ROW3..     -1.0      ..COST..     -1.0
  ...X3...  ..ROW1..      1.0      ..ROW2..      3.0
  ...X3...  ..ROW3..      1.0      ..COST..     -1.0
  ...X4...  ..ROW1..      1.0      ..ROW2..      4.0
  ...X4...  ..ROW3..     -1.0      ..COST..     -1.0
  ...X5...  ..ROW1..      1.0      ..ROW2..     -2.0
  ...X5...  ..ROW3..      1.0      ..COST..     -1.0
  ...X6...  ..ROW1..      1.0      ..ROW2..      1.0
  ...X6...  ..ROW3..      1.0      ..COST..     -1.0
  ...X7...  ..ROW1..      1.0      ..ROW2..      1.0
  ...X7...  ..ROW3..      1.0      ..COST..     -1.0
  ...X8...  ..ROW1..      1.0      ..ROW2..      1.0
  ...X8...  ..ROW3..      1.0      ..COST..     -0.1
  ...X9...  ..ROW1..      4.0      ..ROW2..      1.0
  ...X9...  ..ROW3..      1.0      ..COST..     -0.3
RHS
  RHS1      ..ROW1..      1.5
  RHS1      ..ROW2..      1.5
  RHS1      ..ROW3..      4.0
  RHS1      ..COST..     1000.0
RANGES
  RANGE1    ..ROW1..      3.5
  RANGE1    ..ROW2..      3.5
  RANGE1    ..ROW3..      6.0
BOUNDS
  LO BOUND  ...X1...     -2.0
  LO BOUND  ...X2...     -2.0
  LO BOUND  ...X3...     -2.0
  LO BOUND  ...X4...     -2.0
  LO BOUND  ...X5...     -2.0
  LO BOUND  ...X6...     -2.0
  LO BOUND  ...X7...     -2.0
  LO BOUND  ...X8...     -2.0
  LO BOUND  ...X9...     -2.0
  UP BOUND  ...X1...      2.0
  UP BOUND  ...X2...      2.0
  UP BOUND  ...X3...      2.0
  UP BOUND  ...X4...      2.0
  UP BOUND  ...X5...      2.0
  UP BOUND  ...X6...      2.0
  UP BOUND  ...X7...      2.0
  UP BOUND  ...X8...      2.0
  UP BOUND  ...X9...      2.0
QUADOBJ
  ...X1...  ...X1...  2.00000000E0  ...X2...  1.00000000E0
  ...X1...  ...X3...  1.00000000E0  ...X4...  1.00000000E0
  ...X1...  ...X5...  1.00000000E0
  ...X2...  ...X2...  2.00000000E0  ...X3...  1.00000000E0

```

```

...X2...  ...X4...  1.00000000E0  ...X5...  1.00000000E0
...X3...  ...X3...  2.00000000E0  ...X4...  1.00000000E0
...X3...  ...X5...  1.00000000E0
...X4...  ...X4...  2.00000000E0  ...X5...  1.00000000E0
...X5...  ...X5...  2.00000000E0
ENDATA

```

### 10.3 Program Results

nag\_opt\_handle\_set\_linconstr (e04rjc) Example Program Results

Reading MPS file: e04rjce.opt

#### MPSX INPUT LISTING

```

-----
Searching for indicator line
Line      1: Found NAME indicator line
           Query mode - Ignoring NAME data.
Line      2: Found ROWS indicator line
           Query mode - Counting ROWS data.
Line      7: Found COLUMNS indicator line
           Query mode - Counting COLUMNS data.
Line     26: Found RHS indicator line
           Query mode - Ignoring RHS data.
Line     31: Found RANGES indicator line
           Query mode - Ignoring RANGES data.
Line     35: Found BOUNDS indicator line
           Query mode - Counting BOUNDS data.
Line     54: Found QUADOBJ indicator line
           Query mode - Counting QUADOBJ data.
           Query mode - End of QUADOBJ data. Exit

```

#### MPSX INPUT LISTING

```

-----
Searching for indicator line
Line      1: Found NAME indicator line
Line      2: Found ROWS indicator line
Line      7: Found COLUMNS indicator line
Line     26: Found RHS indicator line
Line     31: Found RANGES indicator line
Line     35: Found BOUNDS indicator line
Line     54: Found QUADOBJ indicator line
Line     64: Found ENDATA indicator line

```

MPS/QPS file read.

The problem was set-up

E04SV, NLP-SDP Solver (Pennon)

```

-----
Number of variables      9          [eliminated      0]
                        simple linear  nonlin
(Standard) inequalities    18          6          0
(Standard) equalities      0          0
Matrix inequalities        0          0 [dense      0, sparse      0]
                                [max dimension      0]

```

```

-----
it|  objective |  optim |   feas |  compl |  pen min |inner
-----
 0  0.00000E+00  4.70E+00  0.00E+00  1.00E+01  1.00E+00  0
 1 -6.76762E+00  9.46E-04  0.00E+00  6.25E-01  1.00E+00  4
 2 -7.82467E+00  1.79E-03  3.69E-02  1.45E-01  4.65E-01  4
 3 -8.02059E+00  7.27E-03  2.27E-02  3.38E-02  2.16E-01  4
 4 -8.06187E+00  3.18E-03  5.75E-03  7.86E-03  1.01E-01  4
 5 -8.06653E+00  1.30E-03  1.13E-03  1.83E-03  4.68E-02  5
 6 -8.06739E+00  6.98E-03  1.42E-04  4.25E-04  2.18E-02  3
 7 -8.06775E+00  2.16E-04  2.80E-05  9.89E-05  1.01E-02  2
 8 -8.06778E+00  4.44E-05  6.94E-05  2.30E-05  4.71E-03  1
 9 -8.06778E+00  1.88E-06  1.15E-05  5.35E-06  2.19E-03  1
10 -8.06778E+00  4.38E-08  1.52E-06  1.24E-06  1.02E-03  1
11 -8.06778E+00  6.52E-10  1.74E-07  2.90E-07  4.74E-04  1
12 -8.06778E+00  8.12E-12  1.90E-08  6.73E-08  2.21E-04  1

```

```
-----
Status: converged, an optimal solution found
-----
```

Final objective value	-8.067778E+00
Relative precision	1.518278E-09
Optimality	8.116995E-12
Feasibility	1.900689E-08
Complementarity	6.734260E-08
Iteration counts	
Outer iterations	12
Inner iterations	31
Linesearch steps	43
Evaluation counts	
Augm. Lagr. values	56
Augm. Lagr. gradient	44
Augm. Lagr. hessian	31

```
-----
```

Optimal solution:

```
2.000000
-0.233332
-0.266666
-0.299997
-0.100004
2.000000
2.000000
-1.777812
-0.455547
```

---